DRAFT FINAL EE/CA

Engineering Evaluation/Cost Analysis Bayou Verdine Area of Concern

Prepared for:

Conoco Inc.
Sasol North America Inc.

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LIST OF ACRONYMS

AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirements
AVE	Average
BERA	Baseline ecological risk assessment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COPC	Constituents of potential concern
COPI	Constituents of potential interest
EE/CA	Engineering Evaluation/Cost Analysis
EDC	1,2-dichloroethane
EqP	Equilibrium partitioning
ERL	Effects range-low
ERM	Effects range-median
GCL	Geosynthetic clay layer
GPS	Global positioning system
HDPE	High density polyethylene
HHRA	Human health risk assessment
HQ	Hazard quotient
ICP	Inductively coupled plasma
LDEQ	Louisiana Department of Environmental Quality
LNHP	Louisiana Natural Heritage Program
LPDES	Louisiana Pollutant Discharge Elimination System
MTBE	Methyl Tertiary Butyl Ether
NCP	National Contingency Plan
NEI	Nature and extent investigation
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
O&M	Operation and maintenance
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PQL	Practical quantitation limit
RECAP	Risk Evaluation/Correction Action Program
RME	Reasonable maximum exposure
SPLP	Synthetic Precipitation Leaching Procedure
SVOC	Semivolatile organic compound
SQG	Sediment quality guidelines
T&E	Threatened and endangered species

LIST OF ACRONYMS

TBC	To-be-considered
TCLP	Toxicity Characteristic Leaching Procedure
TIE	Toxicity identification evaluation
TOC	Total organic carbon
TSS	Total suspended solids
USACE	US Army Corps of Engineers
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
VOC	Volatile organic compound

This Engineering Evaluation/Cost Analysis (EE/CA) is for the Bayou Verdine Area of Concern of the Calcasieu Estuary. It was prepared on behalf of Conoco Inc. (hereinafter "Conoco") and Sasol North America Inc. (hereinafter "Sasol", formerly CONDEA Vista Company) to Support a Non-Time Critical Removal Action. This EE/CA provides various alternatives for the eventual performance of a Response Action for Bayou Verdine that will be conducted under USEPA's CERCLA § 106 Authority. The EE/CA is used as the primary decision document for evaluating alternative actions and providing a mechanism for public involvement in the Response Action process. This EE/CA is consistent with the National Contingency Plan and USEPA guidance.

BACKGROUND

The Calcasieu Estuary is located in the vicinity of Lake Charles in Calcasieu Parish, Louisiana. The estuarine portion of the Calcasieu watershed extends from the saltwater barrier, north of Lake Charles, to the Gulf of Mexico. The Calcasieu River/Calcasieu Ship Channel is joined by several tributaries within the estuary including Bayou Verdine. Historical discharges, permitted discharges, as well as agricultural and industrial stormwater runoff, and accidental spills have contributed to chemical loading of surface water, sediment, and biota within the estuary system. In addition, the Calcasieu Estuary has also been affected by a number of physical alterations such as construction of the Calcasieu Ship Channel and dredging of the river and the various estuary's bayous. The Calcasieu Estuary has been the subject of a number of environmental investigations by both public and private parties, including the investigations performed by Conoco and Sasol in Bayou Verdine, which have led to this EE/CA.

Bayou Verdine is a wetland bayou located within the Calcasieu Estuary, southwest of the city of Westlake and slightly northwest of the city of Lake Charles. Bayou Verdine's headwaters originate in a predominantly agricultural area immediately north and northwest of the Conoco and Sasol facilities and flow in a generally south-southeast direction, subject to tidal influences, through the Conoco facility before entering Calcasieu River at Coon Island Loop. Due to its location within the watershed, this system likely receives non-point source input from agricultural and from urban drainage. Accompanying these potential non-point sources are the past and current input from industrial and urban drainage ditches (including West Ditch and Faubacher Ditch).

SITE CHARACTERIZATION

This EE/CA summarizes the history and background information regarding Bayou Verdine, and details the additional investigations conducted in support of the evaluation of removal action alternatives. A more thorough presentation of Site conditions, particularly information concerning the nature and extent of contamination in sediment and surface water, the biological survey and the ecological risk assessment, can be found in the following publicly available documents that are incorporated by reference:

1) *Bayou Verdine Investigation: Volume I, Nature and Extent Investigation, Lake Charles, LA* (NEI Report). ENTRIX Inc., October 12, 1999.

2) *Bayou Verdine Investigation, Volume II: Screening Level Ecological Risk Assessment, Lake Charles, LA.* ENTRIX Inc., November 3, 1999.

3) *Bayou Verdine Investigation, Volume III, Baseline Ecological Risk Assessment, Lake Charles, LA* (BERA). ENTRIX Inc., March 30, 2001.

4) *Bayou Verdine Investigation, Volume IV, Baseline Human Health Risk Assessment, Lake Charles, LA* (HHRA). ENTRIX Inc., April 12, 2001.

For the purposes of this EE/CA, the "Site" or "Bayou Verdine Area of Concern" is defined as the discrete portion of the Bayou Verdine channel extending upstream 2.9 miles from its mouth and its tributaries and each of their associated surface water, sediments, soil, biota, adjoining shoreline and banks, riparian habitats and wetlands. The 2.9 mile Bayou Verdine channel was subdivided into four spatially distinct reaches extending from 0.5 miles upstream of the Conoco facility to Coon Island Loop.

The NEI identified the chemical constituents of potential interest in Site surface sediments and surface water and provided an evaluation of the spatial extent of these constituents. The NEI results were consistent with historical data in that relatively few compounds are detectable in Bayou Verdine surface water. Constituents detected in sediments included volatile organic compounds, polycyclic aromatic hydrocarbons, metals, pesticides, polychlorinated biphenyls, and semivolatile organic compounds. The HHRA provided a quantification of the potential risk to humans exposed to site constituents and the BERA provided an evaluation of risks to potential ecological receptors.

RESPONSE ACTION SCOPE

There are two distinct areas within the Bayou Verdine Area of Concern: the West Ditch Area and the Main Channel. These two areas have different characteristics and therefore are addressed separately in the EE/CA. The response actions for both areas will address sediments and certain soils within limits defined based on an evaluation of the distribution of constituents, the potential risks associated with exposure to these constituents, and practical considerations.

West Ditch Area

Elevated 1,2-dichloroethane (EDC) concentrations were detected in sediments of Bayou Verdine in a relatively localized portion of the Site near the confluence of West Ditch and Bayou Verdine. A sediment removal action concentration goal of 289 mg/kg EDC (wet weight) was calculated using the exposure factors from the HHRA and a conservative target carcinogenic risk level of 1×10^{-6}. To provide added protectiveness, the limits of the removal actions described in this EE/CA extend beyond the limits of the 289 mg/kg concentration goal. Alternatives that involve dredging or excavating the sediments include the sediments and the upper six inches of underlying clay. Assuming a removal depth of 3 feet throughout the West Ditch Area, the estimated volume of sediments to be addressed by dredging/excavation alternatives is 2,600 in-place cubic yards.

Main Channel

The Main Channel Area includes the four reaches of the Bayou Verdine Area of Concern, not including the West Ditch Area. The HHRA indicates that human health risks associated with sediment contact are within the acceptable range for the Main Channel. The response action for the Main Channel will be implemented to provide protection to ecological receptors by targeting areas where sediment constituents have the greatest potential for adverse effects. The scope of the Main Channel removal action is defined based on constituent distributions and practical considerations as summarized below:

> **Reach 1 –** This reach is south of Interstate 10 and downstream of the Conoco facility to Coon Island Loop. Elevated constituent concentrations are distributed throughout the sediments in the upper portion and in isolated areas within the middle portion. The removal

action will address the upper and middle portions of the reach (beginning at the bridge approximately 800 feet upstream of Coon Island Loop and continuing upstream approximately 4,800 feet to Interstate 10). Downstream of the bridge, the weight of evidence indicates that only localized sediments exhibit toxicity. These downstream sediments will be addressed through natural recovery so the habitats will not be disturbed by the removal action. No dredging will be conducted where the bayou crosses under Interstate 10 or other crossings.

Reach 2 – This reach traverses the Conoco refinery property with industrial activity on both sides. Elevated constituent concentrations were found in the sediments within this reach of the Bayou. The removal action will address the entire length of Reach 2 except where the bayou intersects roads and other crossings.

Reach 3 – This reach is also upstream of most of the historical and current industrial activity. There are localized areas with potential impaired sediment quality, but the weight of evidence suggests that there would be minimal risk reduction by addressing these localized areas. In addition, this reach of the bayou is shallow and winding with a heavily wooded shoreline causing implementability concerns. Reach 3 will be allowed to continue to recover naturally except for the most downstream section near Old Trousdale Road, which is part of the West Ditch Area described above.

Reach 4 – This reach is upstream of the major point-source discharges and is considered outside of the influence of historical and current industrial discharges. The removal action will not be implemented within Reach 4.

Sediment profiles revealed that most constituents were located within the top several inches of the sediments with lesser quantities occurring at mid-depth and the lowest quantities in the native clay layer. An exception to this trend was observed in the upper portion of Reach 1, where the highest constituent concentrations were detected in the 12- to 15-inch interval. Alternatives that involve dredging will address the upper 1 foot of material in Reach 2 and the lower portion of Reach 1, and 2 feet of material in the upper portion of Reach 1. The total estimated amount to be dredged is approximately 17,700 in-place cubic yards of sediment.

ALTERNATIVES CONSIDERED

A range of remedial technologies were considered that include natural recovery, various containment technologies, excavation and dredging, onsite thermal desorption, offsite disposal in a landfill and offsite incineration. These technologies were assembled into the following alternatives:

West Ditch Area

- Alternative WD-1 - Natural Recovery
- Alternative WD-2 - Removal and Offsite Incineration/Disposal
- Alternative WD-3 - Removal and Onsite Thermal Desorption
- Alternative WD-4 - Containment/Capping

Main Channel

- Alternative MC-1 - Natural Recovery
- Alternative MC-2 - Dredging and Offsite Disposal
- Alternative MC-3 - Dredging and Onsite Consolidation
- Alternative MC-4 - Containment/Capping

A detailed analysis was conducted for each alternative based on the EE/CA evaluation criteria of effectiveness, implementability and cost. A comparative analysis was then conducted, comparing the alternatives' performance against these criteria.

RECOMMENDED ALTERNATIVES

Considering the relative performance of the alternatives against the EE/CA evaluation criteria, the recommended removal action alternatives are Alternative WD-2 (Dredging and Offsite Incineration/Disposal) for the West Ditch Area and Alternative MC-3 (Dredging and Onsite Consolidation) for the Main Channel as described below.

West Ditch Area

Sediments will be removed from the West Ditch Area and transported offsite for incineration/disposal. A barrier system and cover will then be placed over the underlying clay.

Removal - The removal action will include sediments within the West Ditch Area that are above the risk-based removal action concentration, and 0.5 feet of the underlying clay. Two potential removal options are presented in this EE/CA, removal with a vacuum truck and removal with a hybrid mechanical/hydraulic dredge. The selected removal option will be determined in the design phase. Temporary diversion structures will be installed to divert the bayou during the removal activities.

Off-Site Incineration/Disposal - Some of the material removed from the West Ditch Area will likely be subject to land disposal restrictions. Accordingly, this material will be transported offsite to a permitted commercial hazardous waste incinerator. Excavated materials that are not subject to land disposal restrictions will be disposed of at an offsite disposal facility permitted to accept the waste.

Barrier System and Cover - A competent barrier system will be constructed on top of the underlying clay. Conceptually, the barrier system will consist of the following three layers from the bottom up:

1. A barrier layer directly on top of the clay to impede the vertical movement of water and sediments;

2. A protective layer to protect the barrier layer; and

3. Sand/silt cover material to provide a substrate with a texture similar to natural conditions (minimum of one-foot thick).

There are three options for barrier system configurations presented in this EE/CA. The configuration to be used will be determined in the design phase.

Main Channel

Sediments will be dredged from sections within the Bayou Verdine channel. The dredged material will be pumped to the Trousdale Road Ponds (two ponds located on the west side of the Conoco facility) where the sediments will settle out and consolidate. A soil cover will be constructed over the Trousdale Road Ponds, the area will be regraded and vegetation will be established. Post-construction monitoring of the Trousdale Road Ponds will be conducted.

Dredging - Sediments will be dredged from sections within Reaches 1 and 2 of the Bayou Verdine channel that have the greatest potential to affect Site risks. The dredging will consist of one pass with a small hydraulic dredge to remove the upper nominal 1-foot of sediments. A second pass will be made over the northern section of Reach 1 to remove an additional 1-foot of material.

Consolidation - The dredged sediments will be pumped to the Trousdale Road Ponds. The sediments in the Trousdale Road Ponds will be allowed to settle and dewater, and the water will be pumped through a multimedia filter and then to Conoco's permitted Wastewater Treatment facility.

Cover Placement - After consolidation, a geotextile and geogrid will be placed over the dredged material in the ponds to provide a suitable base for heavy equipment and the overlying cover layer. A soil cover will be placed over the geotextile/geogrid and the area will be regraded to be consistent with the surrounding topography. The area will be vegetated with grasses or other appropriate upland plants to maintain the integrity of the cover.

Post-Removal Sampling and Monitoring – Post-removal sampling will be conducted to measure the progress of natural recovery in the surficial sediment layer. Groundwater monitoring will be conducted for the Trousdale Road Ponds and there will also be monitoring of the competency of the cover system. A 5-year monitoring period is assumed.

This document presents the Engineering Evaluation/Cost Analysis (EE/CA) for the Bayou Verdine Area of Concern of the Calcasieu Estuary. This EE/CA was prepared on behalf of Conoco Inc. (hereafter "Conoco") and Sasol North America Inc. (hereafter "Sasol", formerly CONDEA Vista Company), in accordance with that certain Administrative Order on Consent for an Engineering Evaluation/Cost Analysis to Support a Non-Time Critical Removal Action (AOC)[1]. This EE/CA has been prepared consistent with the National Contingency Plan (40 CFR 300 *et seq.*) (NCP) and the United States Environmental Protection Agency (USEPA) *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA* (EPA 540-R-93-057) (USEPA, 1993).

1.1 BACKGROUND

The Calcasieu Estuary is located in the vicinity of Lake Charles in Calcasieu Parish, Louisiana (Figure 1-1). The Calcasieu River flows approximately 160 miles from its headwaters to the Gulf of Mexico. The estuarine portion of the Calcasieu watershed extends from the saltwater barrier, north of Lake Charles, to the Gulf of Mexico. The Calcasieu Estuary is characterized by a number of distinctive physical features, including Lake Charles, Prien Lake, Moss Lake, and Lake Calcasieu. The Calcasieu River/Calcasieu Ship Channel is joined by several tributaries within the estuary, the most notable being Bayou Verdine, Contraband Bayou, Bayou d'Inde, and Bayou Olsen. The Intercoastal Waterway connects the Calcasieu Estuary with the Sabine Lake system to the west, and Grand Lake to the east.

The land surrounding the Calcasieu Estuary includes undeveloped, rural residential, commercial, and heavy industrial properties. Heavy industry dominates the southern reaches of Bayous d'Inde and Verdine on both sides. Historical discharges, permitted discharges (as identified in the National Pollution Discharge Elimination System; NPDES), as well as agricultural and industrial drainage ditches (including the West Ditch, the Faubacher Ditch, and the Kansas City Southern Railroad West Ditch), discharge to the Calcasieu Estuary. These discharges (current and historic), stormwater runoff municipal wastewater treatment plant discharges, and accidental spills have contributed to chemical loading of surface water, sediment, and biota within the estuary system. In addition, the Calcasieu Estuary has also been affected by a number of physical alterations. Construction of the Calcasieu Ship Channel in 1941 has altered the salinity regime of the Calcasieu

[1] Administrative Order On Consent For An Engineering Evaluation And Cost Analysis To Support A Non-Time Critical Removal Action. U.S. EPA Docket No. 6-08-02. Respondents: Conoco Inc. and Sasol North America Inc. February 15, 2002.

Estuary and impacted marsh areas to the west of Calcasieu Lake. Water control structures were installed by the United States Fish and Wildlife Service (USFWS) to reduce these impacts.

In addition, much of the Calcasieu River and portions of the various estuary's bayous were dredged or rerouted during the 1950s. For example, the southernmost 3,500 feet of the Bayou Verdine was rerouted to the west when Olin Corporation built a pond over the original bayou. Moreover, periodic navigational dredging is conducted to facilitate access by ocean-going vessels and/or barge traffic. These physical alterations have most certainly contributed to the stresses on the Calcasieu Estuary.

The Calcasieu Estuary currently supports a recreational fishery primarily targeted on sea trout, redfish, black drum, and flounder. In addition, commercial fisheries for shrimp and crab exist in the southern portions of the Calcasieu Estuary, primarily in the Calcasieu Ship Channel. However, fish consumption advisories have been issued in the estuary to protect human health from adverse effects associated with the ingestion of contaminated fish. Although the Calcasieu Estuary is not used as a drinking water source, the surface waters have been designated by the Louisiana Department of Environmental Quality (LDEQ) as supporting primary contact recreation, secondary contact recreation, and fish and wildlife propagation.

The Calcasieu Estuary is not, nor has it been proposed for inclusion, on the National Priorities List. Notwithstanding, the Calcasieu Estuary has been the subject of a number of environmental investigation by both public and private parties, including the investigations performed by Conoco and Sasol in Bayou Verdine which have led to this EE/CA.

Bayou Verdine is a wetland bayou located within the Calcasieu Estuary, southwest of the city of Westlake and slightly northwest of the city of Lake Charles in Calcasieu Parish. Bayou Verdine's headwaters originate in a predominantly agricultural area immediately north and northwest of the Conoco and Sasol facilities and flow in a generally south-southeast direction, subject to tidal influences, through the Conoco Facility before entering Calcasieu River at Coon Island Loop. A map which generally depicts Bayou Verdine is presented in Figure 1-1.

The need for this EE/CA is based on USEPA's, Conoco's and Sasol's desire to identify an appropriate Response Action in order to mitigate any potential human health and/or ecological risk in Bayou Verdine associated with the Companies' operations and to resolve any concomitant statutory liability.

1.2 RESPONSE ACTION OVERVIEW

This EE/CA provides various alternatives for the eventual performance of a CERCLA Response Action for Bayou Verdine that will be conducted under USEPA's §106 Removal Action Authority.

USEPA has categorized Removal Actions in three ways: emergency, time-critical, and non-time-critical, based on the type of situation, the urgency and threat of the release or potential release, and the subsequent time frame in which the action must be initiated. The Response Action described in this EE/CA will entail a non-time removal action because the action can start later than 6 months after the determination that a response is necessary.

An EE/CA must be completed for all non-time-critical removal actions as required by Section 300.415(b)(4)(i) of the NCP. The EE/CA is used as the primary decision document for evaluating alternative actions and providing a mechanism for public involvement in the Removal Action process. The EE/CA scope, as defined in USEPA 1993, includes the following elements:

- Compilation of site characterization data and presentation of a streamlined risk evaluation;
- Development of the response action objectives;
- Development and analysis of removal action alternatives based on effectiveness, implementability, and cost; and
- Recommendation of the removal action alternative that best meets the objectives.

Following public review of and comment on this EE/CA, USEPA will develop an Action Memorandum. The Action Memorandum is a concise, written record of the decision to select an appropriate response action, substantiates the need for a response action, responds to public comments, identifies the proposed action, and explains the rationale for selection.

1.3 ORGANIZATION OF THE EE/CA REPORT

The remainder of this EE/CA is organized in the following sections:

Section 2.0 Site Characterization: Provides a compilation of the Bayou Verdine site characterization data.

Section 3.0 Risk Evaluation: Provide summaries of the Baseline Human Health and Ecological Risk Assessments that have been performed for Bayou Verdine.

Section 4.0 Response Action Goals and Objectives: Provides the goals and objectives of the response action for the Bayou Verdine Area of Concern. Section 5.0 Identification and Analysis of Removal Action Alternatives: Defines the removal action scope, and identifies removal action alternatives that meet the response action goals and objective, and evaluates the performance of these alternatives with respect to effectiveness, cost and implementability.

Section 6.0 Comparative Analysis of Removal Action Alternatives: Provides an evaluation of the relative performance of the removal action alternatives.

Section 7.0 Recommended Removal Action Alternative: Provides a recommended removal action alternative for the Bayou Verdine Area of Concern.

This section summarizes the Site history and background information, and details the investigations conducted in support of this EE/CA. A more thorough presentation of Site conditions, particularly information concerning the nature and extent of contamination in sediment and surface water, the biological survey and the ecological risk assessment, can be found in the following publicly available reports which are incorporated herein by reference: 1) *Bayou Verdine Investigation: Volume I, Nature and Extent Investigation, Lake Charles, LA* (NEI Report); 2) *Bayou Verdine Investigation, Volume II: Screening Level Ecological Risk Assessment, Lake Charles, LA; 3) Bayou Verdine Investigation, Volume III, Baseline Ecological Risk Assessment, Lake Charles, LA* (BERA); *and 4) Bayou Verdine Investigation, Volume IV, Baseline Human Health Risk Assessment, Lake Charles, LA* (HHRA); ENTRIX, 1999a, 1999b, 2001a, and 2001b, respectively. The 1999 reports (Volumes I and II) focus on the results of the field investigations conducted in 1999 to assess:

- Whether chemical constituents were present in sediment and surface water and to evaluate the magnitude and spatial extent of these constituents within the bayou;
- Identify biological resources present within the Bayou Verdine;
- Calculate preliminary estimates of potential ecological risks within Bayou Verdine; and
- Identify chemical constituents that pose potential risk to selected ecological receptors and thus, may require further evaluation in a baseline ecological risk assessment (BERA).

The 2001 reports (Volumes III and IV) present Site baseline human health and ecological risk assessments. The purpose of the HHRA and BERA was to provide an estimate of the potential risk that certain chemical constituents in Site surface water and sediment may pose to human and ecological receptor populations. The hypothetical exposure scenarios and calculated potential risks in the HHRA and BERA are conservative and present a worst case type evaluation.

2.1 SITE DESCRIPTION

2.1.1 Site Location

Bayou Verdine is a wetland bayou located within the Calcasieu Estuary southwest of the city of Westlake and slightly northwest of the city of Lake Charles in Calcasieu Parish. Bayou Verdine's headwaters originate in a predominately agricultural area immediately north and northwest of the Conoco and Sasol facilities and flow in a generally south-southeast direction, subject to tidal influences, through an industrialized area before entering Calcasieu River at Coon Island Loop (Figure 1-1).

2.1.2 Site Description

For purposes of this EE/CA, the "Site" or "Bayou Verdine Area of Concern" is defined as the lower 2.9 miles of Bayou Verdine. The Site is generally bounded downstream at its confluence with the Calcasieu River at Coon Island Loop, and is bounded upstream generally at a point approximately 0.5 miles upstream of Old Trousdale Road. Within this area, the Site includes the Bayou Verdine channel and its tributaries and each of their associated surface water, sediments, soil, biota, adjoining shoreline and banks, riparian habitats and wetlands. The areal extent of the Site is generally depicted on Figure 2-1.

During the NEI, the Site was divided into four spatially distinct reaches, which are as follows:

Reach 1: This reach is bounded downstream by Coon Island Loop and upstream by the Interstate 10 overpass. This reach is approximately 1 mile in length.

Reach 2: This reach is bounded on the downstream end by the overpass of Interstate 10 and on the upstream end by the bridge at Old Trousdale Road, approximately 100 feet upstream of the confluence of the west ditch and Bayou Verdine. This reach is approximately 0.7 miles length.

Reach 3: This reach is bounded on the downstream end by the bridge at Old Trousdale Road and on the upstream end by the bridge at New Trousdale Road. This reach is approximately 0.7 miles in length.

Reach 4: This reach is bounded on the downstream end by the bridge at New Trousdale Road and extends approximately 0.5 miles upstream of this point.

These Reaches are depicted on Figure 2-1.

The Site adjoins agricultural, residential, commercial and industrial properties. The primary land use along Reaches 1, 2, and 3 of Bayou Verdine is industrial. Commercial land use is present farther west from the north end of Reach 1 and the south end of Reach 2, along Interstate 10 and Highway 90. Former residential and some current residential areas are present north of the area of industrial land use on the north side of Reach 3. Rural and some residential land use is present farther north of the bayou in Reach 4. The watershed upstream of Reach 4 includes agricultural and residential land uses.

Due to its location within the watershed, this system likely receives non-point source input from agricultural lands encompassing its northern reaches, and from Faubacher ditch. Faubacher ditch serves as an urban drainage system for the city of Westlake and flows through the current Conoco property prior to its discharge directly into Bayou Verdine (National Oceanic and Atmospheric Administration (NOAA, 1997). Accompanying these potential non-point sources are the past and current industrial point source discharges into Bayou Verdine (NOAA, 1997) (ENTRIX, 1999a).

During the 1950's, the southernmost 3,500 feet of Bayou Verdine was rerouted by Olin Corporation when they built a pond over the original bayou. The former route of the Bayou south of Interstate 10 was to the east of its present course, but the confluence with Coon Island Loop was near its present mouth (PRC, 1994). The only reported dredging of Bayou Verdine in recent history was by PPG in 1992 at the North Barge Slip (PRC, 1994). Bayou Verdine is reportedly about 20 feet deep in this area.

2.1.3 Climate

The climate is classified as humid subtropical with a strong marine character. Winds are typically light and the prevailing wind flow is southerly during much of the year. The annual average temperature is 69° Fahrenheit (ºF). Average temperatures for January and July are 56°F and 81°F, respectively. The average annual rainfall is 54.05 inches. Rainfall amounts are substantial during all seasons. Almost all rainfall occurs from brief convective showers, except occasionally during winter when nearly continuous frontal rains may persist for a few days. In spite of the large normal rainfall amounts, dry spells of two or three weeks duration are not uncommon.

The winter months are normally mild with cold spells usually of short duration. Temperatures of 20° F and below are extremely rare, occurring only about one year in five. Snow is negligible. Many years pass without measurable snowfall.

The summer weather is consistently warm and humid but the temperature rarely reaches 100°F. The humidity is often above 90 percent at night and seldom falls below 50 percent during the afternoons.

The spring and fall seasons are very mild with brief rains interrupting periods of dry sunny weather.

The area weather is occasionally influenced by tropical storms or hurricanes. The National Weather Service (NWS, 1998) indicates that severe storms occur in the area with the following frequencies:

- A tropical storm passes through the area (based on a 150 nautical mile radius of Lake Charles) about every 1.6 years;
- A hurricane passes through the area every 3.3 years; and
- A major hurricane passes through the area every 14 years. The longest break in tropical storm activity was 7 years (1905-1912).

Some of these storms may be accompanied by tornadoes.

2.1.4 Topography

The Site area consists of low-lying flatlands at elevations generally less than 20 feet NGVD. The topography slopes towards Bayou Verdine from both sides, ranging from 10 to 15 feet NGVD away from the bayou to 5 feet NGVD or less at the bayou.

2.1.5 Regional Hydrology

The Calcasieu Estuary is characterized as a humid subtropical woodland and wetland system. The major hydrologic feature in the estuary is the Calcasieu River and Ship Channel, which extends southward to Calcasieu Lake and the Gulf of Mexico. Bayou Verdine is a tributary of the Calcasieu River and is located within the 100-year floodplain of the Calcasieu River Basin (PRC, 1994).

Bayou Verdine's headwaters originate in a predominately agricultural area immediately north and northwest of the Conoco and Sasol facilities and flow in a generally south-southeast direction, subject to tidal influences, through a industrialized area before entering Calcasieu River at Coon Island Loop. Its headwaters are freshwaters that mix with brackish to saline water of the Calcasieu River to the south. Bayou Verdine enters the Calcasieu River at Coon Island Loop (Figure 1-1).

The areas of Bayou Verdine above Reach 1 generally have water depths of less than 6 feet. Water depths in Reach 1 are generally between 6 and 8 feet. As stated above, the North Barge Slip has been dredged and the water depth is reportedly about 20 feet in this area near the confluence with Coon Island Loop.

According to the 1992 US Fish and Wildlife Service's National Wetland Inventory Map, the uppermost portion of Bayou Verdine is classified as a palustrine aquatic system containing deciduous trees. The middle portion of the bayou is composed of two different habitat types: 1) a riverine segment with a permanently flooded channel; and 2) a palustrine segment dominated by deciduous shrubs that is periodically flooded. All portions of the bayou sampled during the NEI are tidally influenced (ENTRIX, 1999a).

2.1.6 Regional Geology and Hydrogeology

The Site is located within the Gulf Coastal Plain physiographic province of southwestern Louisiana. The area is comprised primarily of unconsolidated Quaternary Pleistocene-age sediments. Structurally, the area consists of a geosyncline that continues to receive large quantities of sediment from multiple river discharges (Louisiana Geological Survey, 1984).

The Quaternary sediments are Pleistocene-age terraces deposited on the Gulf Coastal Plain during glacial retreats (PRC, 1994). These sediments are typically composed of interbedded sands, gravels, silts, and clays. Four terrace deposits have been identified in Calcasieu Parish: the Williana, Bentley, Montgomery, and Prairie. The Bentley, Montgomery, and Prairie are exposed at the surface in Calcasieu Parish. The surficial deposits in the Lake Charles area southwest of Bayou Verdine are clays, silts, fine sand, and shells of the Prairie Terrace (Louisiana Geological Survey, 1984).

At some locations, the Pleistocene terrace deposits may be overlain by Holocene alluvium consisting of sandy and gravelly channel deposits mantled by sandy to muddy natural levee deposits, with organic-rich muddy backswamp deposits in between them (Louisiana Geological Survey, 1999).

Stratigraphy of the shallow deposits in the Site vicinity is generally:

- Intervals of clays, silty clays, clayey silts, and silty clays generally extend from ground surface to depths of near 25 feet below ground surface (bgs). Thin sand intervals that are laterally discontinuous may occur within this interval.

- A sand interval with thickness ranging approximately from 1 to 5 feet occurs near a depth of 25 feet bgs at some locations. This interval is designated the 25-Foot Sand.

- Intervals of silts, clayey silts, silty clays and clays extend from below the 25-Foot Sand to depths ranging approximately from 50 to 80 feet bgs.

- A sandy interval, designated the 50-Foot Sand is generally present in the vicinity. The 50-Foot Sand is generally comprised of layers of interfingering sands, silts, clayey silts, and silty clays.

- The 50-Foot Sand is underlain by clays, silty clays, clayey silts, and silts.

- The 200-Foot Sand (discussed below) of the Chicot aquifer generally occurs at depths starting approximately 130 to 150 feet below ground surface.

The principal aquifer system in the region is the Chicot aquifer. The Chicot aquifer system consists of a complex series of alternating beds of unconsolidated sand, gravel, silt, and clay (Nyman et al., 1990).

The Chicot aquifer system crops out in Louisiana in southern Vernon and Rapides Parishes and in northern Beauregard, Allen, and Evangeline Parishes. The aquifer system thickens and dips to the south at a rate of about 30 feet/mile. Along the southern edge of the outcrop area, water in the aquifer system becomes confined beneath surface clay that thickens to as much as 200 feet downdip. Clay within the aquifer system in the outcrop area generally is thin and discontinuous. Within parts of the outcrop and downgradient areas, the Chicot aquifer system consists of a single relatively massive sand (Nyman et al., 1990). In the Lake Charles area, the Chicot aquifer is divided into the 200-Foot Sand, a 500-Foot Sand and a 700-Foot Sand. The names of these sands were based on average depths of wells completed in each sand. In other areas, the Chicot aquifer is described as including an upper Chicot aquifer and a lower Chicot aquifer.

The Evangeline aquifer underlies the Chicot aquifer system. The Evangeline aquifer generally ranges from 400 to 900 feet in thickness and contains an alternating sequence of relatively thin sand and thick clay beds. Individual sand beds are thinner and finer grained than those of the Chicot aquifer system (Whitfield, 1975; Turcan and others, 1966). Sand in the Evangeline aquifer ranges from fine to coarse.

Clays that confine the Chicot aquifer system thicken consistently from the outcrop to the coastline and range from 1 to 200 feet in thickness. Clays between and within the aquifer units generally are thin from west to east, and clays are thin and discontinuous between Lake Charles and the Atchafalaya River. The clay beds consist primarily of mixed layer clay and smectites, but silt-sized quartz is commonly an important constituent.

2.1.7 Threatened and/or Endangered Species

Threatened and endangered species are those species that have been given special legal and protective designations by federal or state government resource agencies. A federally endangered species is one that is in danger of extinction throughout all or a significant portion of its region. A federally threatened species is one likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (ENTRIX, 1999b).

The USFWS has identified 21 federally threatened or endangered species for the state of Louisiana. A list of these species can be found in the *Bayou Verdine Investigation, Volume I: Nature and Extent Investigation* October, 1999 (ENTRIX, 1999a). The Louisiana Natural Heritage Program (LNHP) also lists species of concern for the state of Louisiana. This list is for the entire state of Louisiana, and is expanded beyond the federal list because it includes species that do not have legal protection, but may be rare in the state or globally. As part of the BERA, the USFWS, the LDEQ, and the LNHP were contacted to identify state and federally listed threatened and endangered plant and animal species occurring in the Bayou Verdine study area. No state or federally listed threatened or endangered species were identified by these agencies for the Bayou Verdine study area (ENTRIX, 1999b).

2.2 SOURCE, NATURE AND EXTENT OF CONTAMINATION

In 1999, Conoco and Sasol commissioned ENTRIX, Inc. to conduct a Site Nature and Extent Investigation (NEI). The NEI was conducted consistent with the *Bayou Verdine Investigation Work Plan, Lake Charles, Louisiana, November 1998*. The NEI was conducted voluntarily, but with USEPA's review and approval. The objectives for the NEI were to identify chemical constituents of potential interest (COPI) in Site surface sediments and surface water and to evaluate the spatial extent of these constituents. Each of the above-defined Reaches 1, 2, 3, and 4 of Bayou Verdine was investigated during the NEI. For sampling activities, each Reach was divided into three subreaches, lower (downstream), middle, and upper (upstream). One water sample was collected and analyzed for each of the 12 subreaches. Of the 108 analytes evaluated in surface water, only eight (chloroform, bromodichloroethane, chlorodibromomethane, methyl tert-butyl ether, vinyl chloride, 1,2-dichloroethane, 1,1,2-trichloroethane, and zinc) were detected above their respective laboratory practical quantitation limits. These results are consistent with historical data in that relatively few compounds are detectable in Bayou Verdine surface water.

Constituents detected in sediments included volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), metals, pesticides, polychlorinated biphenyls (PCBs), and semivolatile organic compounds (SVOCs).

An assessment of spatial variation in the concentrations of selected classes of constituents of potential interest (COPI) in surface sediments was made in the NEI Report (ENTRIX 1999A) using total PAHs (the sum of 13 individual PAHs) and total metals (the sum of 12 individual metals). Statistical analyses demonstrated that, in general, the Site is separated into two spatial components having significantly different concentrations of these two variables. Surface sediments occurring upstream of New Trousdale Road contained an average of 4.7 mg total PAH/kg and 249 mg total metals/kg whereas sediments downstream of New Trousdale Road contained 22.2 mg total PAH/kg and 764 mg total metals/kg. No other gradients in the concentration of these constituent classes were evident.

The NEI Report (ENTRIX, 1999a) contains a comprehensive compilation of information available regarding the nature and extent of Site sediment and surface water contamination.

2.3 NEI ANALYTICAL DATA

2.3.1 Surface Water Results

Surface water samples collected from Bayou Verdine during the March 1999 NEI sampling event were analyzed for various organic and inorganic compounds. All surface water samples collected were analyzed for the comprehensive analyte suite, which included selected VOCs, SVOCs, petroleum hydrocarbons, metals, and inorganic constituents. An expanded analyte suite included the comprehensive suite with the addition of pesticides and PCBs. During the NEI, one surface water sample was collected in each of the three subreaches within each Reach except in Reach 1 Subreach A (the most downstream portion of the Site), where duplicate surface water samples were collected. Therefore, concentration values in all subreaches (except R1A) are based on single samples collected from the center point of each subreach.

Results of laboratory analyses indicated that seven VOCs were detected in surface water samples at concentrations greater than the respective practical quantitation limits (PQL) for those constituents (Table 2-1). No other VOC compounds analyzed were detected in surface water at concentrations greater than their respective PQLs. Chloroform, bromodichloroethane, chlorodibromomethane, vinyl chloride, 1,2-dichloroethane, and 1,1,2-trichloroethane were detected only in the lower three reaches. Methyl tert-butyl ether (MTBE) was the only VOC detected in Reach 4.

Results of laboratory analyses also indicated that no SVOCs, pesticide compounds, PCBs (Aroclors) or PAHs were detected in concentrations above laboratory PQLs in any of the surface water samples collected from Bayou Verdine.

Zinc was the only metal found in concentrations greater than the Practical Quantitation Limit in surface waters within the study area. Zinc was detected in four of the 12 subreaches sampled (Table 2-1).

2.3.2 Sediment Results

Sediments were collected at various depths within Bayou Verdine and analyzed for organic and inorganic constituents. All sediment samples collected from Bayou Verdine were analyzed for the comprehensive analytical suite, which included VOCs, SVOCs, PAHs, metals and inorganic constituents. One sediment sample collected from each of the 12 subreaches was randomly selected and analyzed for the expanded analyte suite that included pesticides and PCBs. For the surface sediments, there were a total of 50 analytes out of 134 analyzed that were detected in Bayou Verdine sediments above the laboratory PQL (Table 2-2) (ENTRIX, 1999a).

Results of laboratory analyses indicated that fifteen VOCs were detected above the PQLs, and these accounted for approximately 30% of all the constituents detected in Site surface sediments. These VOCs were 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-dichloroethene, trans-1,2-dichloroethene, acetone, benzene, chlorobenzene, chloroform, methyl ethyl ketone, tetrachloroethene, toluene, trichloroethene, and total xylenes (Table 2-2).

Results of laboratory analyses indicated that 13 PAHs and three other SVOCs were detected above the PQLs and these accounted for roughly 26% of the compounds detected in Site surface sediments. PAHs detected were acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, and pyrene (Table 2-2). SVOCs detected were bis(2-chloroethyl)ether, bis(2-ethylhexyl)phthalate and phenol.

Results of laboratory analyses indicated that 12 metals were detected above the PQLs and these accounted for approximately 24% of the total number of constituents detected. These metals were arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, and zinc (Table 2-2).

Results of laboratory analyses indicated that 7 PCBs/pesticides were detected above the PQLs and these accounted for approximately 14% of the total number of constituents detected. These included 4-4'DDT, aldrin, alpha-BHC, Aroclor 1248, Aroclor 1254, gamma-BHC (lindane), and methoxychlor (Table 2-2).

Of the 134 constituents analyzed in sediments during this investigation, the COPI screening process for sediment identified 42 COPIs that were quantified above their PQLs (Table 2-2). All other constituents analyzed in sediments were either below PQLs or were below screening benchmark values and were not further evaluated.

Several sediment physicochemical parameters were also measured as a part of this investigation. The parameters investigated for this field study were sediment bulk density (wet weight), percent moisture, particle size (percent sand, silt and clay), total organic carbon (TOC), simultaneously extracted metals/acid volatile sulfide and total sulfides (Table 2-2).

2.3.3 Sediment Depth Profiles

In addition to surface sediment samples, subsurface sediment samples were collected at seven locations within Bayou Verdine. Three sediment samples (surface, mid depth, and bottom) were collected from each of the seven cores and analyzed for the expanded analyte suite. Sediment profiles revealed that most constituents were located within the top several centimeters of the sediments with lesser quantities occurring at mid-depth and the lowest quantities in the native clay layer. An exception to this trend was observed at the core collected in the northern portion of Reach 1, where the highest PAH concentrations were detected in the mid depth (12- to 15-inch) interval. Table 2-3 illustrates the vertical distribution of constituents from the core samples (ENTRIX, 1999a). Depth profiles for VOCs in the West Ditch Area were later investigated in the EE/CA studies as discussed below in Section 2.5.3.

2.4 CHARACTERIZATION OF EDC IN WEST DITCH AREA SEDIMENTS

During the NEI and subsequent investigations, elevated 1,2-dichlorethane (EDC) concentrations were detected in the West Ditch Area sediments in a relatively localized area near the confluence of the West Ditch and Bayou Verdine.

Sediment samples collected from this area contained up to 1.9% EDC (by weight), whereas there were only four detectable concentrations in the remainder of the bayou and these four samples ranged from 11 to 16 µg/kg. Additional investigation of the West Ditch Area was conducted to support this EE/CA as discussed in Section 2.5.3.

2.5 EE/CA STUDIES

The following studies were performed by URS during the preparation of this EE/CA for the purpose of determining the feasibility of the removal actions and developing the cost estimates:

- Geotechnical Testing of the Bayou Verdine Sediments
- Treatability Testing of Dredge Discharge Water Conditions
- Supplemental West Ditch Area Characterization
  - Sampling and analysis of sediments and measurement of sediment thicknesses
  - Surveying of top of clay (bottom of bayou) elevation

These studies are described below, and the results are incorporated into the detailed evaluation of alternatives presented in Section 5.0.

2.5.1 Geotechnical Testing

Core samples for geotechnical tests were collected to evaluate the dredging feasibility and costs, and also to evaluate the settling efficiency of the material after it is dredged. The cores were collected from eight sediment sample locations within Bayou Verdine. One sediment core was collected from the upper portion of Reach 3; three sediment cores were collected from Reach 2; and four sediment cores were collected from Reach 1. The core locations are shown on Figure 2-2.

The sediment cores were collected by advancing thin-walled Shelby tubes approximately 18 inches into the substrate of the bayou. The Shelby tubes were capped on both ends after retrieval to prevent desiccation and taped for added support. The tubes were placed in a hard cooler in a vertical position and carefully handled until shipment to the URS geotechnical lab in Totowa, New Jersey. The core samples were tested for the following:

- Total (Bulk Unit Weight with Water Content) - ASTM D2937
- Combined Sieve and Hydrometer Analysis - ASTM D422
- Organic Content - ASTM D2974

The results are summarized on Table 2-4. The grain size distribution curves are presented in Appendix A.

The samples from Reach 1 were generally described as low to high plasticity clays (CL to CH) with 58.7 to 75.2 percent fines (i.e., silt and clay size particle range passing the No. 200 sieve). The organic content ranged from 0.1 and 0.5 percent; the percent water ranged from 28.4 to 37.5 percent; and the total unit weight ranged from 92.9 pounds per cubic foot (pcf) to 114.9 pcf.

The three samples from Reach 2 were described as sandy clay (SC), sandy clay with organics (SC-SO), and organic clay (CL-OL). The organic content ranged from 0.3 to 1.3 percent. The fines ranged from 31.4 percent in the sandy clay to 68.8 percent in the organic clay. The percent water ranged from 21.1 percent in the sandy clay to 59.1 percent in the organic clay. The unit weight ranged from 79.6 pcf in the organic clay to 123.9 pcf in the sandy clay.

The sample from Reach 3 was an organic clay (CL-OL), with an organic content of 0.9 percent. The percent water was 39.6 percent; the bulk density was 89.3 pcf; and 71.3 percent passed the No. 200 sieve.

Most of the material from the cores was in the clay to silt size particle range with a bulk density of about 90 to 105 pcf. Samples from Reach 2 consisted of a heavier and a more sandy material than the other samples. For the purpose of evaluating remedial alternatives and estimating costs, the mean values of all eight samples for percent water and bulk density were assumed. These values are shown on Table 2-4.

2.5.2 Treatability Testing of Dredge Discharge Water Conditions

Some of the alternatives that are described in Section 5.0 involve dredging the Bayou Verdine sediments and pumping the material into two onsite ponds (Trousdale Road Ponds) for consolidation. Treatability testing was conducted to evaluate the quality of the water that would be discharged from the ponds after allowing the dredged material to settle. Testing was also conducted to simulate the reduction in total suspended solids that would occur by simulating treatment through a sand filter after settling and prior to discharge.

The potential contaminant release into the water associated with a dredging operation was evaluated using the Modified Elutriate Test (USEPA/USACE, 1994). This test is designed to simulate the overlying water concentrations within a holding facility (i.e., similar to the ponds designated for consolidation). The tests were performed on three co-located grab samples of water and sediment collected from Reaches 1 and 2 of the bayou. The samples were collected from the core sample locations described in Section 2.5.1 and shown on Figure 2-2. At each location, approximately one quart of sediment was collected with an Ekman grab sampler, and approximately 10 gallons of water were collected directly into two 5-gallon plastic containers. The sediment and water were shipped on ice to the URS laboratory in Franklin, Tennessee.

As recommended by USEPA/USACE 1994, an initial sediment slurry concentration of 150 g/L was used with a settling period of 24 hours. The initial sediment concentration is considered a close approximation to the typical dredging production, whereas the settling time of 24 hours is a suggested default value. This is a conservative approximation; the actual settling time should be greater than 24 hours due to the capacity of the ponds.

The unfiltered samples that were generated after the 24 hours of settling were collected, placed in sample jars provided by the analytical laboratory, and shipped on ice to the Severn Trent Analytical laboratory in Austin, Texas. The samples were analyzed for the following:

- Inductively Coupled Plasma (ICP) Metals and Trace (ICP) Metals (Method 6010B);
- Mercury (Method 7470A);
- Organochlorine Pesticides (Method 8081A);

- Polycyclic Aromatic Hydrocarbons by HPLC (Method 8310);
- Semivolatile Organic Compounds (Method 8270C);
- Volatile Organic Compounds (Method 8260B);
- Alkalinity (Method 310.1);
- Nitrate as N (Method 300.0A);
- Ammonia (Method 350.3 for water, 350.2 for solids);
- Total Hardness (Method 130.2);
- Total Kjeldahl Nitrogen (Method 351.2);
- Total Dissolved Solids (Method 160.1);
- Biological Oxygen Demand (BOD) (Method 405.1);
- Chemical Oxygen Demand (COD) (Method 410.4); and
- TOC (Method 9060 for water and 415.1 for soil).

The samples were also tested in the URS Franklin, Tennessee laboratory for total suspended solids (TSS), pH, and specific conductance.

A second sample was collected and treated using a bench-scale sand filter. Due to limited sample volume, this sample was only analyzed for TSS in the Franklin, Tennessee laboratory.

The test results are summarized in Table 2-5 and the analytical data package is presented in Appendix B. The results were evaluated in combination with the estimated water production rate (presented in Section 5.0). These results indicate that the existing water treatment system at the Conoco facility has the capability and sufficient capacity to treat the water from the dredging operations that are described in Section 5.0.

2.5.3 West Ditch Area

2.5.3.1 Sediment Sampling and Analyses and Measurement of Sediment Thickness

URS collected cores of sediment and the upper 1-foot of underlying clay on October 5 and 6, 2001. The cores were collected at six locations from Bayou Verdine in the West Ditch Area as follows (Figure 2-3):

- C-1 approximately 300 feet downstream (east) of the Old Trousdale Bridge;
- C-2 approximately 150 feet downstream of the Old Trousdale Bridge;
- C-3 approximately 75 feet downstream of the Old Trousdale Bridge;
- C-4 approximately 30 feet downstream of the Old Trousdale Bridge;
- C-5 approximately 10 feet upstream (west) of the Old Trousdale Bridge; and
- C-6 approximately 150 feet upstream of the Old Trousdale Bridge.

Cores were collected by pushing 3-inch diameter aluminum vibracore sampling tubes through the sediments and 1-foot into the underlying clay. Each core tube was then taken to a work station adjacent to the bayou and the tube was cut open lengthwise. The core was then logged by a geologist and samples of sediment and clay were collected for chemical analysis. Samples of sediment were collected for chemical analysis at 1 foot intervals in the sediments and at depths of 0.5-foot and 1-foot intervals within the clay. The samples for chemical analysis were placed in labeled sample jars and placed on ice in ice chests. The samples were then transferred under chain of custody to personnel from Gulf Coast Analytical Laboratory Inc. (GCAL), who transported them for analysis in the GCAL laboratory in Baton Rouge, Louisiana. A trip blank, two equipment rinsate samples, and four field duplicate samples were also analyzed.

The sediment and clay samples were analyzed for volatile organics by Method SW846 8260B. In addition, four samples were tested by the Synthetic Precipitation Leaching Procedure (SPLP) Method SW846 1312 and the Toxicity Characteristic Leaching Procedure (TCLP) Method SW846 1311. The leachate from the SPLP and TCLP tests were analyzed for volatile organics by Method SW846 8260B.

Analytical results for all constituents detected (wet weight basis) are included in Table 2-6. EDC was detected in one or more sediment samples at locations C-3, C-4, C-5, and C-6 at concentrations ranging from 4.9 to 6,360 mg/kg (wet weight basis). At all of these locations the highest sediment EDC concentrations were detected in the deepest samples. EDC was detected in clay samples from locations C-1, C-3, C-4, C-5, and C-6 at concentrations ranging from 0.064 to 22,700 mg/kg (wet weight basis). At all of these locations, the EDC concentrations were substantially lower at 1-foot into the clay than at one-half foot into the clay.

The highest EDC concentrations in the sediment and clay were located in the area from approximately 30 feet west of the bridge over Old Trousdale Road downstream to near the confluence of the West Ditch with Bayou Verdine.

The samples tested by SPLP and TCLP were as follows:

- Core C-3 clay from a depth of 0.5 foot;
- Core C-4 sediment from a depth of 2 feet;
- Core C-5 sediment from a depth of 2 feet; and
- Core C-5 clay from a depth of 1 foot.

Table 2-7 presents the analytical results for the leachate from these tests. The concentrations from the SPLP and TCLP tests are similar. The TCLP results for all four samples exceed the regulatory limit of 0.5 mg/l for characterization as hazardous waste by toxicity characteristic.

The thickness of sediment was measured in this area during the October 5 and 6, 2001 core sampling. The sediment thickness was probed at intervals of approximately 20 feet in the upstream to downstream direction and at intervals of approximately 10 feet across the bayou. Measured sediment thicknesses generally ranged from 1.5 feet to 3.5 feet. Figure 2-3 shows the resulting estimated sediment thickness contours.

2.5.3.2 Survey of Elevation of Top of Clay Underlying the Sediments

The sediments in Bayou Verdine in the West Ditch Area are underlain by clay. The top of this clay represents the bottom of the sediments deposited in the bayou.

URS surveyed the top of the clay underlying the sediments in the West Ditch Area of Bayou Verdine on October 25, 2001. The top of the clay was probed at spacings of approximately 5 feet in the upstream-downstream direction and across the bayou. The area surveyed extended from approximately 250 feet upstream (west) of the Old Trousdale Road bridge to approximately 500 feet downstream of the Old Trousdale Road bridge. The top of clay was surveyed to a relative elevation based on a bench mark on a concrete pillar that was assigned an arbitrary elevation of 100 feet.

Figure 2-4 shows the elevation of the top of the clay. A low in the surface of the top of clay is present immediately downstream of the Old Trousdale Road bridge to approximately 50 feet upstream of the bridge. A smaller low in the surface of the clay occurs midway between the West Ditch confluence and the Old Trousdale Road bridge.

This section summarizes the results of the HHRA and BERA.

3.1 BASELINE HUMAN HEALTH RISK ASSESSMENT

The results of the HHRA (as summarized in ENTRIX, 2001b) are:

- "A baseline human health risk assessment was conducted in the lower 4.5 km portion of Bayou Verdine in the vicinity of Conoco's Lake Charles refinery. The human use of the bayou is currently industrial. However, the state classifies Bayou Verdine as being available for both primary and secondary contact recreation. Consequently, this assessment characterized potential risks to hypothetical human receptor populations who may engage in limited recreational activities in the study area and may hypothetically contact chemicals present in bayou surface water, sediment and biota (fish and shellfish). Hypothetical receptor populations evaluated in this human health risk assessment included: recreational swimmers; recreational waders; workers; and biota consumers. Potentially complete exposure pathways included incidental ingestion and dermal contact with surface water and sediment, as well as consumption of fish and shellfish. Both average (AVE) and reasonable maximum exposure (RME) scenarios were evaluated for each hypothetical receptor. Recreational activities in the bayou related to the scenarios evaluated have not been observed or reported in the study area.

- In 1999 and 2000, a total of 134 chemicals were analyzed in 12 surface water samples and 96 sediment samples. A preliminary screening procedure was performed for chemicals in sediment and surface water in order to identify chemicals that were likely to contribute significantly to hypothetical risks.

- Potential risks were calculated for the following hypothetical receptors: recreational swimmers in Reaches 1 and 4, recreational waders in Reaches 2 and 3, and biota (fish and shellfish) consumers in Reaches 1 and 4. Risks were estimated for both average (AVE) and reasonable maximum exposure (RME) scenarios.

- The AVE potential cumulative carcinogenic risks for exposure to COPCs constituents of potential concern "in sediment and surface water were all below

$1x10^{-6}$ for the following hypothetical receptors: recreational swimmers (Reaches 1 and 4), recreational waders (Reaches 1 and 4), and workers (Reaches 2 and 3). The RME cumulative potential carcinogenic risks for exposure to COPCs in sediment and surface water were all within the acceptable risk range of $1x10^{-6}$ and $1x10^{-4}$ for the following hypothetical receptors: recreational swimmers (Reaches 1 and 4), recreational waders (Reaches 1 and 4), and workers (Reaches 2 and 3). The majority of the potential RME cumulative carcinogenic risks are attributed by hypothetical dermal contact with benzo(a)pyrene (62-73%).

- The potential AVE cancer risks for hypothetical recreational and subsistence fish and shellfish consumers (Reaches 1 and 4) are within the acceptable risk range of $1x10^{-6}$ and $1x10^{-4}$. The potential RME cancer risks for hypothetical recreational and subsistence fish and shellfish consumers (Reaches 1 and 4) are greater than $1x10^{-4}$. The majority of the potential RME carcinogenic risk for hypothetical recreational and subsistence biota consumers is attributed by consumption of fish tissue[2].

- The potential AVE and RME hazard indices for hypothetical exposure to COPCs in sediment and surface water for the recreational swimmers (adult and youth; Reaches 1 and 4), and workers (Reaches 2 and 3) are all below unity.

- The potential AVE hazard index for hypothetical adult recreational fish and shellfish consumers is less than unity and the potential RME hazard index is greater than unity. The majority of the potential RME hazard index for hypothetical adult recreational biota consumers is attributed by Aroclor 1254 (80%) in fish tissue.

- Since information concerning consumption rate of turtle was not readily available, risks due to consumption of turtle were evaluated qualitatively. It was assumed that turtle consumption rates were similar to shellfish consumption rates. Therefore since potential AVE and RME cancer and noncancer risks for hypothetical shellfish consumption do not exceed the acceptable risk range, and concentrations of

[2] The HHRA (ENTRIX 2001b) presented estimates of risk based on consumption of fish and shellfish. Based on comments provided by USEPA, the risk estimates were revised to reflect that the arsenic is not 100 percent available (see Attachment 1).

COPCs in turtle tissue were lower than those detected in blue crab, it is unlikely that consumption of turtle from Bayou Verdine will cause adverse health effects to hypothetical turtle consumers.

- The potential AVE and RME hazard indices for hypothetical adult and youth subsistence fish and shellfish consumers are greater than unity. The majority of those hazard indices for hypothetical subsistence consumption of biota are attributed by Aroclor 1254 (67-80%) in fish tissue.

- Due to limited access and aesthetics, Bayou Verdine is not a known recreational area. However, access to the bayou is not restricted in Reaches 1 and 4. Therefore, risks were conservatively estimated for hypothetical exposure to COPCs in the study area. Estimated potential RME risks likely represent overestimates of risk. Calculated potential AVE risks more likely represent recreational usage of the study area, if it were to occur.

- Based on results of the risk characterization, it does not appear that COPCs driving potential risks for consumption of biota (fish and shellfish) are resulting from concentrations of COPCs in sediment or surface water in the study area. Since biota are mobile, they may contact additional sources outside the study area.

- The chemical contributing to the majority of RME potential risks for direct contact with sediment is benzo(a)pyrene, while risks from biota consumption are primarily attributed by Aroclor 1254 in fish tissue. If remediation were undertaken to reduce risks from sediment contact, a parallel reduction in risks due to biota consumption would not be achieved."

Human Health Risk Assessment Conclusions for the West Ditch Area were:

- "The estimated potential carcinogenic risk from hypothetical dermal contact with EDC in surface water and sediment is $6X10^{-8}$ and $3x10^{-5}$ for the average (AVE) and reasonable maximum exposure (RME) worker exposure scenarios, respectively. The estimated potential AVE cancer risk is below $1x10^{-6}$ and the estimated potential RME cancer risk is within the acceptable risk range of $1x10^{-6}$

and $1x10^{-4}$. The majority of the RME potential carcinogenic risk is attributable to hypothetical dermal contact with EDC in sediment.

- The estimated potential noncarcinogenic risk (hazard index) from hypothetical dermal contact with EDC in surface water and sediment is 0.002 and 0.3 for the AVE and RME worker exposure scenarios, respectively. Both the potential AVE and RME hazard indices are less than unity.

- Any hypothetical contact by workers with sediment or surface water in the EDC Footprint Area would be accidental. In addition, it was assumed that Conoco workers work in accordance with Conoco's health and safety plan, which provides health and safety guidelines for activities within the facility which should prevent or minimize opportunities to fall into the bayou. Therefore, potential risks were conservatively estimated for hypothetical exposure to EDC in the EDC Footprint Area. Estimated RME risks likely represent overestimates of risk. Calculated AVE potential risks more likely represent hypothetical incidental contact with surface water and sediments in the EDC Footprint Area."

3.2 BASELINE ECOLOGICAL RISK ASSESSMENT

The results of the BERA (as summarized in ENTRIX, 2001a) were:

- "A comprehensive, baseline ecological risk assessment was conducted in the lower 4.5 km portion of Bayou Verdine in the vicinity of Conoco's Lake Charles refinery. The goal of this assessment was to characterize risks to selected species from exposure to chemicals found in bayou surface water and sediment, as well as in various dietary items in the bayou. Species selected for risk characterization included sediment dwelling organisms (benthic invertebrates), birds (Great Blue Heron, Belted Kingfisher, and American Coot), and terrestrial mammals (Muskrat and Mink). Dietary items for these receptors that were collected from the bayou included Gulf Menhaden, Blue Crab, Bullfrogs, and Alligator Weed.

- In 1999 and 2000, a total of 134 chemicals were analyzed in 12 surface water samples and 96 sediment samples. In surface water, only four (4) chemicals were found to exceed analytical detection limits; however, none of these were found to exceed water quality criteria benchmarks. In sediment, 58 chemicals were detected of which 47 were found to exceed sediment quality benchmarks (e.g., effects range-low [ERL]). These 47 chemicals, including metals, polycyclic aromatic hydrocarbons (PAH), semi-volatile and volatile organic compounds, and pesticides, were the constituents of potential interest (COPI) for the baseline risk assessment.

- For forty-three (43) of the COPIs, ecological risks to birds and terrestrial mammals were negligible, having hazard quotients (HQ) less than 1.0. The remaining four (4) COPIs (chromium, selenium, zinc, and benzo[a]anthracene) yielded HQs in the range of 1-4, reflecting minimal risk to bird and mammal receptors. Given the conservative assumptions made in this risk characterization (e.g., 100% bioavailability of chemicals and 100% of diet coming directly from the bayou), risks to upper trophic level receptors are minimal.

- Ecological risks to aquatic species inhabiting the water column were negligible, since no COPI was found to exceed toxicological benchmarks for this medium.

- A sediment pore water toxicity identification evaluation (TIE) suggested that non-polar organic compounds (e.g., PAHs) were the major contributors to toxicity, based on Microtox® assays. Metals in pore water were not found to contribute to toxicity. The suggestion that metals did not contribute to pore water (i.e., aqueous) toxicity was supported by an AVS/SEM analysis of sediment, which found that divalent metals were not bioavailable.

- Metal residues measured in tissues of Gulf Menhaden, Blue Crab and Bullfrogs collected from Bayou Verdine were similar to residues in menhaden and crab collected in other parts of the estuary in 1984-1985 and in frogs from unimpacted areas outside Louisiana. Based on this comparison, menhaden, blue crab, and frogs are not accumulating metals at concentrations greater than those found historically within and outside the estuary.

- The sediment Triad analysis indicated that sediments were toxic to the amphipod *Hyalella azteca* in laboratory tests, particularly in sediments located in the lower one-half of the bayou. Analytical chemistry data indicated that concentrations of a number of chemicals exceeded sediment quality benchmarks (e.g., ERL). A benthic survey indicated a depauperate community in Bayou Verdine compared to historical surveys that were conducted in other parts of the estuary. Integrating other lines of evidence, such as the TIE and AVS/SEM analyses, suggested that non-polar organic compounds (PAHs) and sulfide were the major contributors to toxicity and relatively low community structure characteristics. An analysis based on the equilibrium partitioning (EqP) between sediment and pore water suggested that PAHs are bioavailable, which further supported their contribution to sediment benthos toxicity.

- Ecological risk was confined to sediment dwelling (benthic) organisms. Multiple environmental stresses, primarily PAHs and sulfide, as well as variations in dissolved oxygen and salinity, were found to be the most important factors responsible for this risk. This risk was not equally distributed over the study area; the highest risks were confined to sediments located in the lower two-thirds of the bayou. In the absence of anthropogenic chemical stressors, other natural physical and chemical stressors are present in Bayou Verdine that may be adversely impacting the benthic community."

Baseline Ecological Risk Assessment Conclusions for the West Ditch Area were:

- "EDC yielded hazard quotients (HQs) in the range of 1-5 for heron, kingfisher, and muskrat, reflecting potential risk to bird and mammal receptors based on the maximum sediment concentration in the footprint area. These risk estimates were driven solely by incidental sediment ingestion. Given that the HQs based on mean exposures were less than 1.0 and the conservative assumptions made in this risk characterization (e.g., 100% bioavailability of chemicals and use of the maximum EDC sediment concentration), risks to upper trophic level receptors are minimal.

- Ecological risk was indicated to sediment dwelling (benthic) organisms. This risk was not equally distributed over the footprint area; the highest risks were confined to nine (9) samples located within the area in Bayou Verdine.

- Ecological risk was not indicated for fish and other aquatic species, given that the chronic criterion for EDC in water was orders of magnitude greater than the maximum EDC concentration observed in the bayou."

4.1 RESPONSE ACTION GOAL

The goal of this response action is to protect human health and the environment from potential risks that may arise from the presence of Site constituents within the Bayou Verdine Area of Concern. This goal can be achieved through the implementation of one or more of the removal action alternatives described herein.

4.2 RESPONSE ACTION OBJECTIVES

A number of factors must be considered when establishing specific response action objectives. The objectives must satisfy applicable or relevant and appropriate requirements (ARAR's) and address site-specific conditions. Site-specific response action objectives were developed consistent with the NCP and the current state of knowledge of Site characterization data and risk evaluation. These Site-specific objectives were used as the basis for development of each of the removal action alternatives presented in Section 5.0. The Site-specific objectives are:

- Develop a profile of site conditions to define the response action objectives;
- Define the removal action scope;
- Identify appropriate removal action alternatives;
- Evaluate the effectiveness of the removal action alternatives;
- Evaluate the implementability of the removal action alternatives; and
- Evaluate the cost of the removal action alternatives.

The profile of site conditions and the response action objectives are discussed below; the remaining objectives are discussed in Section 5.0.

The response action will be performed entirely within the Bayou Verdine Area of Concern. As discussed in Section 2.0 herein, Bayou Verdine has been divided into four reaches that extend from Coon Island Loop to approximately 0.5 miles north of new Trousdale Road. Within the Bayou Verdine Area of Concern, there are two distinct areas: the West Ditch Area and the Main Channel. These two areas have different characteristics that may require different actions, and therefore are addressed separately in this EE/CA. The response action objectives within these two areas are defined based on the profile of site conditions, including an evaluation of the distribution of constituents and the potential risks associated with exposure to these constituents. The removal actions for both areas will only address sediments and certain soils. The surface water and groundwater media will not be addressed in this action. Based upon the risk assessments, the surface water media was determined to not be contributing to potential risks. The groundwater media underlying the Bayou Verdure Area of Concern was determined to be largely unaffected by releases to Bayou Verdine, with the exception of the area at the confluence of West Ditch and Bayou Verdine. Any necessary response work for groundwater in the West Ditch Area will be performed pursuant to a separate action under the jurisdiction and review of the LDEQ.

West Ditch Area

Elevated 1,2-dichloroethane (EDC) concentrations were detected in the Bayou Verdine sediments in a relatively localized portion of the Site near the confluence of West Ditch and Bayou Verdine. The NEI sampling indicated sediment samples from this area contained up to 1.9% EDC (dry weight), whereas concentrations detected in other sections of the bayou ranged from 11 to 16 µg/kg (dry weight). Subsequent investigations of the West Ditch Area for this EE/CA have better defined Site conditions and the distribution of constituents. The results of these investigations are presented in Section 2.5.3.

The HHRA (ENTRIX, 2001b) provided a conservative evaluation of the potential risk to workers from accidental exposure to the sediments by falls into the West Ditch Area. Based on this evaluation, the estimated potential noncarcinogenic risks are in the acceptable range of 0.003 to 0.2 for the average (AVG) and reasonable maximum exposure (RME) scenarios, respectively. The estimated potential carcinogenic risk ranges from 6×10^{-8} to 2×10^{-6} for the AVG and RME exposure scenarios, respectively. A majority of the hypothetical risk is attributed to dermal contact with EDC in the sediments. The assumptions and exposure factors used to develop these scenarios are presented in the HHRA. A sediment removal action concentration goal was calculated for this EE/CA using the RME exposure factors and a conservative target carcinogenic risk level of 1×10^{-6}. The calculated sediment removal action concentration for EDC in the West Ditch Area is 289 mg/kg (wet weight)[3].

[3] The removal action concentration was calculated by ENTRIX Inc. based on an industrial worker being exposed to EDC in sediment under the RME exposure factors from the HHRA.

The BERA (ENTRIX, 2001a) addresses potential exposure to ecological receptors. The EDC concentrations observed in the sediment resulted in HQs in the range of 1 to 5 for the heron, kingfisher and muskrat. These risk estimates were driven solely by incidental sediment ingestion and are based on exposure to the maximum detected sediment concentration. HQ's were all below unity using the average sediment concentration of 1,219 mg/kg (wet weight), which is well above the removal action concentration of 289 mg/kg for protection of human health. Therefore the 289 mg/kg removal action concentration will also be protective of the bird and mammal receptors.

Based on this evaluation, the response action objective for the West Ditch Area is to address sediments above 289 mg/kg. The removal action scope is further defined in Section 5.1, with consideration of practical issues such as technical feasibility and implementability.

Main Channel

The Main Channel includes the four reaches of the Bayou Verdine Area of Concern, excluding the West Ditch Area. The removal action for the Main Channel will benefit ecological receptors by targeting areas where sediment constituents have the greatest potential for adverse effects. The HHRA indicates that human health risks associated with sediment contact are within the acceptable range for the Main Channel.

Ecological risk associated with exposure to the sediments is evaluated in the BERA via the sediment Triad. The Triad integrates three components or measures of sediment quality: sediment chemistry, sediment toxicity, and benthic community structure. The Triad analysis presented in the BERA indicated that sediments were toxic to the amphipod *Hyallella azteca* in laboratory tests, particularly in sediments located in the lower one-half of the bayou (Reaches 1 and 2). Analytical chemistry data indicated that concentrations of a number of chemicals exceeded sediment quality guidelines (SQGs). A benthic survey indicated a depauperate community in Bayou Verdine compared to historical surveys that were conducted in other parts of the estuary. Integrating other lines of evidence from the BERA, such as the toxicity identification evaluation (TIE) and acid volatile sulfides/simultaneously extracted metals (AVS/SEM) analyses, suggested that non-polar organic compounds (PAHs) and sulfide were the major contributors to toxicity and relatively low community structure characteristics. An analysis based on the equilibrium partitioning (EqP) between sediment and pore water suggested that PAHs are bioavailable, which further supported their potential contribution to toxicity.

A weight of evidence approach based on the sediment Triad is used to define the response action objectives for the Main Channel. Comparison of sediment concentrations to Effects Range-Median (ERM) SQGs in combination with the distribution of the EqP indices is used to target the more degraded sediments within Bayou Verdine so that the removal action will provide the greatest benefit from reduction of Site risks while minimizing disturbance of existing habitat. Figure 4-1 summarizes the ERM Quotients and EqP results within Bayou Verdine. Considering these multiple lines of evidence, the response action objectives for the Bayou Verdine Area of Concern are:

Reach 1 – The response action objective for Reach 1 is to implement the removal action within the upper and middle portions of the reach (beginning at the bridge approximately 800 feet upstream of Coon Island Loop and continuing upstream approximately 4,800 feet to Interstate 10).

There are isolated areas of potential impaired sediment quality in the lowermost portions of Reach 1, but there is a general trend of increasing sediment quality proceeding downstream in this area. This trend is supported by the PAH concentrations; four of the five samples downstream of the bridge have ERM quotients for total PAHs of less than 0.5. The one sample that exceeds 0.5 (UCST028) is located at the confluence of Bayou Verdine and Coon Island Loop in an area of potential influences from outside of Bayou Verdine. There is predicted toxicity from PAHs in three of the samples downstream of the bridge (including UCST028) using the EqP approach. However, this predicted toxicity is not completely supported by the toxicity testing. While there was toxicity indicated in UCST028, the other sample tested from this area produced lesser effects and inconsistencies between the two test organisms. The maximum positive benefit for Reach 1 would be affected by implementing the removal action for the sediments upstream of the bridge. Downstream of the bridge, the weight of evidence indicates that only localized sediments exhibit toxicity. These downstream sediments will be addressed through natural recovery so the habitats will not be disturbed by the removal action.

Reach 2 – Areas of impaired sediment quality are distributed throughout Reach 2 as summarized on Figure 4-1. The response action objective to provide maximum benefit for Reach 2 is to implement the removal action for the entire reach upstream of Interstate 10.

Reach 3 – The lowermost portion of Reach 3 will be addressed with the West Ditch Area. There are a few, small, isolated areas with potential impaired sediment quality farther upstream in Reach 3, but the weight of evidence suggests that there would be minimal risk reduction by addressing these isolated areas. The response action objective to provide maximum benefit for Reach 3 is to allow natural recovery of this reach upstream of the West Ditch Area.

Reach 4 – Figure 4-1 shows that the sediment quality is not impaired in Reach 4, and therefore the removal action will not be implemented within Reach 4.

5.1 REMOVAL ACTION SCOPE

This section defines the removal action scope for the West Ditch based on the response action goals and objectives presented in Section 4 and practical considerations that may affect removal.

West Ditch Area

The following summarizes the West Ditch Area removal action scope that provides the basis for the alternatives described in Section 5.3.1:

- The estimated horizontal extent of sediments within Bayou Verdine that are impacted at concentrations above the 289 mg/kg removal action concentration is from approximately 30 feet upstream of the bridge at Old Trousdale Road to approximately 160 feet downstream of the bridge. Within the West Ditch, the estimated extent above 289 mg/kg is about 75 feet upstream of its confluence with Bayou Verdine. This covers an area of approximately 11,700 square feet.

- Sediment thickness in the West Ditch Area ranges from about 1.5 to 3.5 feet. The sediment is described as loose, black, silt, high in natural organic content. The underlying clay is described as light brown to gray and very stiff. The sediments and the underlying clay have been impacted by EDC. Generally, the highest concentrations occur in the upper 6 inches of the clay.

- To provide added protectiveness, the limits of the removal action described herein will extend beyond the limits of the 289 mg/kg removal action concentration. As shown on Figure 5-1, the removal action limits will extend from approximately 120 feet upstream of the bridge at Old Trousdale Road to approximately 250 feet downstream of the bridge and will include approximately 140 feet of West Ditch. This encompasses an area of approximately 23,400 square feet.

- Alternatives that involve dredging or excavating the sediments will include the sediments and the upper six inches of clay. Assuming a removal depth of three feet throughout the West Ditch Area, the estimated volume of sediments to be addressed by dredging/excavation alternatives is 2,600 in-place cubic yards.

- Toxicity Characteristic Leaching Procedure (TCLP) testing, as per 40 CFR 261.24, of the sediment samples from this area indicates that the some of the material to be removed from that West Ditch Area would likely be classified as a D028 characteristic hazardous waste. The samples for TCLP testing (Table 2-7) were generally collected from the sediments with higher total EDC concentrations. It is likely that some of the excavated material will not fail the TCLP tests and can be handled as nonhazardous waste.

Main Channel

In addition to the response action goals and objectives described in Section 4.0, practical considerations were also taken into account to define the Main Channel removal action scope. These practical considerations include technical feasibility and implementability due to the locations of obstructions including pipelines, bridges and other bayou crossings that would impede the efficiency and effectiveness of any action. Based on these factors, the following summarizes the Main Channel removal action scope:

Reach 1 – This reach is south of Interstate 10 and downstream of the Conoco facility to Coon Island Loop. The removal action will address the upper and middle portions of the reach (beginning at the bridge approximately 800 feet upstream of Coon Island Loop and continuing upstream approximately 4,800 feet to Interstate 10). No dredging will be conducted where the bayou crosses under Interstate 10 or other crossings.

Reach 2 – This reach traverses the Conoco refinery property with industrial activity on both sides. The removal action will address the entire length of Reach 2 except where the bayou crosses under roads and other crossings.

Reach 3 – This reach is also upstream of most of the historical and current industrial activity. There are localized areas with potential impaired sediment quality, but the weight of evidence suggests that there would be minimal risk reduction by addressing these localized areas. In addition, this reach of the bayou is shallow and winding with a heavily wooded shoreline causing implementability concerns. Reach 3 will be allowed to continue to recover naturally except for the most downstream section near Old Trousdale Road, which is part of the West Ditch Area described above.

Reach 4 – The sediment quality is not impaired in Reach 4, and therefore this reach is not included in the removal action scope

The following summarizes conditions that provide the basis for the removal action alternatives presented the Section 5.3.2.

- The removal action limits as defined above include approximately 7,300 linear feet (369,000 square feet) of the Bayou Verdine channel.

- Sediment profiles revealed that most constituents were located within the top several inches of the sediments with lesser quantities occurring at mid-depth and the lowest quantities in the native clay layer. An exception to this trend was observed at the core collected in the northern portion of Reach 1, where the highest PAH concentrations were detected in the mid depth (12- to 15-inch) interval. Alternatives that involve dredging will address the upper 1 foot of material in Reach 2 and the lower portion of Reach 1, and 2 feet of material in the upper portion of Reach 1. The limits of the section of bayou with 2-foot removal is bounded to the south by a sharp bend in the bayou near where there is a core showing lower concentrations in the deeper interval, and bounded to the north by Interstate 10. The total estimated removal volume is approximately 17,700 in-place cubic yards of material.

- The sediments tested for geotechnical properties from Reach 1 and Reach 2 were in the clay to silt size particle range with a bulk density ranging from 79.6 to 123.9 pcf and percent water ranging from 21.1 to 59.1%. Samples from Reach 2 consisted of a heavier and a more sandy material than the samples from Reach 1. The organic content of the sediments ranged from 0.1 to 1.3 percent.

5.2 EVALUATION CRITERIA

The alternatives are evaluated against the short- and long-term aspects of the three criteria: effectiveness, implementability, and cost in accordance with the "Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA", EPA 540-R-93-057, August 1993 (USEPA, 1993).

Effectiveness

The effectiveness of an alternative refers to its ability to achieve the response action goals and objectives presented in Section 4.0. The evaluation considers the following:

Overall Protection of Human Health and the Environment - This criterion addresses whether the removal action is protective of human health and the environment from potential risks that may arise from the presence of Site constituents within the Bayou Verdine Area of Concern. The alternatives are evaluated against their ability to provide additional protection for human and ecological receptors by targeting the West Ditch Area and other areas within the Main Channel where sediment constituents have the greatest potential to impact Site risk.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) and Other Criteria, Advisories, and Guidance - Section 300.415(I) of the National Contingency Plan requires that fund-financed removal actions under CERCLA Section 104 and removal actions pursuant to CERCLA Section 106 attain ARARs under Federal or State environmental laws or facility siting laws, to the extent practicable considering the urgency of the situation and the scope of the removal.

In the event that an ARAR does not exist, other pertinent guidelines and standards should be considered. These are commonly referred to as to-be-considered (TBC). State and federal guidelines are examples of TBCs. Potential ARARs are divided into three categories: chemical-specific, action-specific and location-specific as summarized below:

- Chemical-specific - Chemical-specific ARARs define the acceptable concentration of a constituent that must be attained by remedial actions based on federal and state laws that are ARARs. The removal actions described in this EE/CA are limited to sediments in the Main Channel, and sediments and underlying soils in the West Ditch Area. There are not any promulgated cleanup criteria that have been established for sediments. The LDEQ Risk Evaluation Corrective Action Program (RECAP) (LDEQ, 2000) provides cleanup standards for soils and groundwater, but does not specifically address sediments.

- Location-specific - Location-specific ARARs are restrictions placed on an activity or on the concentration of a hazardous substance solely because they occur in specific locations. The location-specific ARARs are summarized in Table 5-1 and discussed below in the detailed analysis of each alternative.

- Action-specific - Action-specific ARARs are technology- or activity-based requirements or limitations on actions taken. The action-specific ARARs are also summarized in Table 5-1 and discussed in the detailed analysis of each alternative.

Table 5-1 identifies potential action- and location-specific ARARs and TBCs, classifies each as applicable, relevant and appropriate, or to be considered. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that are not directly applicable to a hazardous substance, pollutant or contaminant, location, or other circumstance at a CERCLA site but address problems or situations sufficiently similar to those encountered at the CERCLA site, and whose use is well suited to the particular site. The judgment of the relevance and appropriateness of a requirement depends on the substances in question and the physical nature of the site. Table 5-1 also provides a summary of the requirements and a description of their applicability.

Section 121(e) of CERCLA exempts onsite response actions from having to obtain a Federal, State, or local permit. In general, onsite actions need only comply with the substantive aspects of ARARs, but not with the corresponding administrative requirements (e.g., permitting). However, actions involving offsite disposal are required under Section 121(d)(3) of CERCLA to meet both administrative and substantive requirements of ARARs.

The action- and location-specific ARARs were considered for the conceptual design of each removal action alternative described below. As the detailed design is developed for the selected alternative, specific technical requirements would be addressed or ARARs waivers requested.

Long-Term Effectiveness and Permanence - This criterion relates to the long-term effectiveness of the alternative in maintaining protection after the response objectives have been met. The focus is on any residual risk remaining at the site after completion of the removal action, whether the benefit from the action is permanent, and also whether the action contributes to future remedial objectives for the site.

Reduction of Toxicity, Mobility, and Volume - Section 121(b)(1) of CERCLA defines the statutory preference for treatment methods that would result in the reduction of toxicity, mobility, or volume of a waste. The specific factors considered were the amount of waste to be destroyed or treated; the expected degree of reduction in toxicity, mobility, or volume; the degree to which the remediation would be irreversible; and the nature and quantity of treatment residuals that would remain Onsite. Because of potential exposure to ecological receptors, both inherent toxicity (the toxicity inherent to the material not considering the fate and transport properties or the potential exposure pathways) and effective toxicity (the toxicity available to the biota) were considered.

Short-Term Effectiveness - Short-term effectiveness relates to the potential for adverse effects to the environment or community during construction and implementation of the removal action. The length of time required to achieve protection, and the short-term reliability of the technology, were also considered.

Implementability

This criterion relates to the technical and administrative feasibility of the removal action. The specific factors that were considered include the ability to construct, operate, and maintain the technology; ability to monitor the effectiveness of the action; and the ability to obtain approvals from other agencies.

Cost

The cost estimates presented in this EE/CA are typically in the +50 percent to -30 percent accuracy range. The estimates were based on a variety of sources, including estimates from remediation contractors, generic unit costs, and conventional cost estimating guides, prior experience, and information from other sites. The estimates have been prepared for guidance in the alternative evaluation from the information available at the time of the estimate. The actual costs of the project would depend on true labor and material costs, actual site conditions, final project scope, the implementation schedule, competitive market conditions, and other variable factors. A significant uncertainty that would affect the cost is the actual volumes of sediment to be removed and/or areas to be covered. Contingencies have been applied to each alternative to take into consideration assumptions and uncertainties associated with the current project scope and unforeseen circumstances. Unless otherwise noted, a 20 percent contingency allowance was used to reflect uncertainties.

Capital and operation and maintenance (O&M) costs were estimated for each alternative and were used to calculate present net worth. Capital costs include the direct and indirect expenditures required to implement a remedial action. Direct costs include construction costs or expenditures for equipment, labor, and materials. Indirect costs include those associated with engineering services, permitting (as required) and legal services, construction services, and other necessary services.

Annual O&M costs include operation labor, maintenance materials, maintenance labor, energy, and other costs needed for continued post-construction operation and maintenance. For purposes of comparing remedial actions, 10 years of operation, maintenance and monitoring were typically utilized in the present net worth calculations at a five-percent discount rate.

The estimated present worth capital and O&M costs are summarized in the alternative analysis presented below. Appendix C includes spreadsheets that provide more detailed cost estimates.

5.3 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

Within the Bayou Verdine Area of Concern, there are two distinct areas, the West Ditch Area and the Main Channel. These two areas have different characteristics that may require different removal actions, and therefore are addressed separately in this EE/CA.

The removal action scope for both areas are discussed in Section 5.1. A range of remedial technologies were considered that include natural recovery, various containment technologies, excavation and dredging, onsite thermal desorption, offsite disposal in a landfill and offsite incineration. These technologies were assembled into the alternatives described below. The individual analysis of alternatives for the West Ditch Area is presented in Sections 5.3.1 and summarized on Table 5-2. The individual analysis for the Main Channel is presented in Section 5.3.2 and summarized on Table 5-3.

5.3.1 West Ditch Area

The following four alternatives were evaluated for the West Ditch Area:

- Alternative WD-1 - Natural Recovery
- Alternative WD-2 - Removal and Offsite Incineration/Disposal
- Alternative WD-3 - Removal and Onsite Thermal Desorption
- Alternative WD-4 - Containment/Capping

5.3.1.1 Alternative WD-1 – Natural Recovery

Alternative WD-1 is natural recovery of the West Ditch Area. Site risks would be reduced by natural sedimentation and degradation of the EDC and other organics over time. Alternative WD-1 includes hydrodynamic and sedimentation studies as well as sediment sampling to evaluate the effectiveness of natural recovery. Baseline monitoring and development of a long-term monitoring plan would be conducted during the first year. Subsequent monitoring would include:

- Annual sediment sampling for site constituents to determine whether concentrations are decreasing with natural recovery.
- Annual surveying of sediment pins at specified locations to quantify the amount of deposition (if any) that is occurring.

It is assumed that the monitoring program would be conducted for a 10-year period.

Effectiveness

Overall Protection of Human Health and the Environment - Natural recovery is likely occurring as sediments carried from upstream in the bayou are deposited in the West Ditch Area and mix with existing sediments thus reducing the concentrations. Natural recovery is also occurring with the natural degradation of the EDC and other organic compounds. These natural recovery processes would cause a decrease in Site risks. The monitoring conducted for Alternative WD-1 would provide data for evaluating the effectiveness of natural recovery.

Compliance with ARARs - None of the location-specific ARARs identified for the site would pertain to Alternative WD-1. There would be no action-specific ARARs.

Long-Term Effectiveness and Permanence - There would be increased protectiveness with natural recovery of the system; however, long-term effectiveness and permanence is uncertain and would be determined from monitoring.

Reduction of Toxicity, Mobility, and Volume - There would be a slow reduction in toxicity, mobility, and volume as organic compounds degrade over time. Effective toxicity (availability) and mobility will gradually decrease as concentrations in the active zone decrease with natural recovery.

Short-Term Effectiveness - There would be no short-term adverse effects associated with this alternative.

Implementability

Alternative WD-1 is easily implementable from a technical basis.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. A detailed cost spreadsheet is presented in Appendix C.

Alternative WD-1 Natural Recovery		
Estimated Capital Cost ($)	**Estimated Present Worth O&M Cost ($)**	**Estimated Present Worth Total Cost ($)**
100,000	160,000	260,000

The estimated capital costs are for the baseline studies and development of a long-term monitoring plan. The O&M costs are for the subsequent monitoring over a 10-year period.

5.3.1.2 Alternative WD-2 – Removal and Offsite Incineration/Disposal

Alternative WD-2 would include removal of the sediments within the West Ditch Area, offsite incineration/disposal of the material, placement of a barrier system, and placement of a cover. The boundary of the removal area would be the horizontal limits shown on Figure 5-1. Within these limits, the sediments and 0.5 feet of the underlying clay soils would be removed.

Removal

The sediment removal activities would be conducted in a manner to minimize the release of volatile constituents, and also to minimize the amount of water that is generated, which potentially would contain EDC and require treatment. Two potential removal options were considered in detail and are presented below. Removal options would continue to be evaluated during the design phase and the option used for removal may be modified somewhat from that presented herein.

Option 1 (Removal with Vacuum Trucks)

- Portable water diversion structures would be installed on the upstream and downstream ends of localized removal areas, and removal would progress from the West Ditch downstream to Bayou Verdine, and then from upstream to downstream within the bayou.
- Removal would be conducted in localized sections of the West Ditch Area. Portable pumps would be used to pump the water from removal areas and also to divert water from the upstream water diversion structure to the downstream structure.

- Removal would be conducted with vacuum trucks and the sediments would be pumped directly into sealed vacuum boxes. Excavation equipment may be used to loosen and scrape the stiffer sediment and underlying clay to the target removal depth and then to feed this material to the vacuum hoses.

- The exhaust from the vacuum trucks would be treated onsite using either vapor-phase carbon or a combination wet scrubber and vapor-phase carbon.

- Any water entering the excavation would be pumped to frac tanks and then to an approved wastewater treatment system. As necessary, shallow sheet piles or other vertical barrier would be driven into the clay in order to contain seepage from the sides.

- The vacuum boxes would be allowed to sit and the material settle out. Water accumulating at the top of the boxes would be periodically decanted and pumped to an approved wastewater treatment system.

<u>Option 2 (Removal with Hybrid Dredge)</u>

- Removal would be conducted with a combination mechanical and hydraulic dredge equipped with a sealed clam-shell bucket. This type of dredge can remove the material at the in-situ water content with minimal resuspension as compared to other dredging technologies.

- Portable water diversion structures would be installed on the upstream and downstream ends of localized removal areas, and removal would progress from the West Ditch downstream to Bayou Verdine, and then from upstream to downstream within the bayou. Water from upstream would be diverted around the removal areas, but sufficient water would be maintained within the removal area to float the dredge and also to maintain a water blanket to minimize the release of volatile organics.

- The dredge material would be placed in a hopper located on the shoreline. The hopper would have a flexible membrane cover and be under negative air pressure so that when the dredge bucket is opened to deposit the material in the hopper, the volatile emissions would be contained. From the hopper, the material would be pumped to a series of sealed filter boxes where water separated from the sediments can be removed and pumped to an approved wastewater treatment system.

- The air exhaust from the negative air device on the hopper, the air displaced from the boxes, and any other exhaust that potentially could contain volatile emissions would be treated onsite with vapor-phase carbon or a combination wet scrubber and vapor-phase carbon.
- The localized areas beneath the Old Trousdale Road Bridge would be removed with either vacuum trucks (as described above) or a small suction-type dredge.

Placement of Barrier System and Cover

After removal within an area using either one of the options described above, a barrier system would be placed on top of the underlying clay. Conceptually, the barrier system would consist of three layers. From the bottom up, the layers are:

1. A barrier layer directly on top of the clay to impede the vertical movement of water and sediments;
2. A protective layer to protect the barrier layer; and
3. A sand/silt cover material at the surface to provide a substrate with a texture similar to natural conditions (minimum of one-foot thick).

It is possible that layers 1 and 2 can be combined into one layer by using a rigid uniform mat of low permeability. There are three barrier system configurations under consideration.

Option 1 - Option 1 would use a grout-injected, fabric-formed, semi-rigid, continuous, 3 to 6-inch liner as both the barrier and protective layer. The technology that would be used to install this layer is commonly referred to as "fabri-forming" or "uniform section lining." Two geotextiles joined together at closely spaced points with drop-strings would be placed on the bayou bottom after removal activities within a section are complete. The interstitial spacing between the geotextiles would be filled by pumping with a grout mixture consisting of sand, cement and bentonite. The drop strings control the layer thickness. During the design phase, the appropriate thickness would be determined, and the grout mixture would be designed to provide the appropriate balance of both sealing/flexibility and rigid protectiveness. After the grout was allowed to cure, the minimum one-foot sand/silt cover layer would be placed.

Option 2 - Option 2 would use a geosynthetic clay layer (GCL) for a barrier, a combination of sand and light riprap for a protective layer, and then the sand/silt layer as cover material. A GCL is a manufactured composite liner consisting of a layer of low-permeability sodium bentonite attached to a fabric or geomembrane. Typically GCLs are shipped in rolls that when deployed are less than 0.25 inches thick. GCL placement requires further evaluation before this option can be selected. There are two concerns; first, the GCL and overlying sand with riprap must be placed at the same time to assure uniform GCL loading as it hydrates; and second, Bayou Verdine water is brackish and the effect of salt water on the GCL permeability must be evaluated. The GCL would be protected by a minimum of 6 inches of sand to evenly distribute the weight of individual riprap rock. Approximately 6 inches of light riprap (i.e., 2-pound stone) would be placed over the GCL and the sand cover to provide protection to the barrier layer. A minimum one-foot sand/silt cover layer would be placed on top of the riprap.

Option 3 - Option 3 would use an HDPE geomembrane for a barrier, a light riprap for protection, and then the sand/silt layer as cover material. To protect the geomembrane, a minimum six-inch layer of sand would be placed on the geomembrane before the protective layer is placed. Approximately six inches of light riprap (i.e., 2-pound stone) would be placed on the geomembrane sand cover as the protective layer. A minimum one-foot sand/silt cover layer would be placed on top of the riprap.

Figure 5-3 shows three potential options for the barrier system and cover. The details of the barrier system to be used for implementation of the alternative will continue to be evaluated during the design phase and may be modified somewhat from that presented herein.

Offsite Incineration/Disposal

It is assumed that some of the excavated material would exceed the TCLP regulatory limit for EDC and be subject to land disposal restrictions. Accordingly, disposal of this material would be at a permitted offsite commercial hazardous waste incinerator. Material that does not exceed the TCLP regulatory limit will be disposed of at an offsite disposal facility permitted to accept the waste. For the purpose of the cost estimate, it is assumed that all of the material would be sent to the offsite commercial hazardous waste incinerator.

Post-Construction Monitoring

Because the affected sediments would be removed, there would not by any subsequent post-construction monitoring of the West Ditch Area.

Effectiveness

Overall Protection of Human Health and the Environment - Alternative WD-2 would be protective because it would eliminate exposure pathways to human and ecological receptors above the removal action concentration established in Section 4.2.

Compliance with ARARs - The alternative could be implemented to comply with the action-specific and location-specific ARARs listed in Table 5-1. A USACE permit would not be required, but the action would have to comply with the substantive requirements of Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act.

LDEQ and USEPA regulations regarding the handling and transportation of hazardous waste would apply. The selected disposal facility would require approval to accept CERCLA waste.

It is assumed that some of the excavated material would be subject to land disposal restrictions.

There have not been any federally-listed threatened and endangered (T&E) species or archeological or historical sites identified within the area to be addressed by the removal action.

Treatment and discharge of generated waters would have to comply with the substantive requirements of the Louisiana Pollution Discharge Elimination System program.

Long-Term Effectiveness and Permanence - Alternative WD-2 would involve permanent removal of contaminated sediments from the West Ditch Area. The barrier system would permanently prevent any future exposure to the underlying clay material.

Reduction of Toxicity, Mobility, and Volume - There would be a reduction in toxicity and volume with incineration and the treated material would be put in a secure landfill. There would be a decrease of volume of contaminated sediments.

Short-Term Effectiveness - A Site-specific Health and Safety Plan would be required to ensure protection of remediation workers during all phases of planning, construction and monitoring of this option. The Health and Safety Plan should also address the necessary procedures to eliminate any potential exposures to people outside of the work area. Appropriate engineering and monitoring controls would be evaluated and implemented as needed in order to protect the remediation workers, plant workers and community from any unacceptable exposure arising from the alternative. There is a small potential for exposure to the community during transportation of the material to the offsite incinerator/disposal facility due to accidental discharge resulting from a traffic accident or other similar incident. This potential would be minimized with proper selection, training and oversight of subcontractors. There is a potential for releases of constituents down the bayou during the removal action; however, this potential would be mitigated through the use of the water diversion structures and the removal methods described above.

The action would take approximately 3 to 6 months to implement.

Implementability

Alternative WD-2 would be moderately difficult to implement. Removal is assumed to be either with a hybrid dredge or vacuum truck, which would be slow. Monitoring and engineering measures to control vapors may also cause some delays. Temporary diversion of the bayou would be difficult and there are concerns about the ability to control the flow. It may not be feasible to divert the bayou during storm events and therefore localized removal areas would have to be completed or protected prior to storm flow. It would also be difficult to handle and transport wet sediments.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. A detailed cost spreadsheet is presented in Appendix C.

Alternative WD-2 Removal and Offsite Incineration/Disposal		
Estimated Capital Cost ($)	**Estimated Present Worth O&M Cost ($)**	**Estimated Present Worth Total Cost ($)**
7,100,000	0	7,100,000

5.3.1.3 Alternative WD-3 – Removal and Onsite Thermal Desorption

Alternative WD-3 would include removal of the sediments within the West Ditch Area, onsite thermal desorption of the material, placement of a barrier system, and placement of cover material. The boundary of the removal area would be the horizontal limits shown on Figure 5-1. Within these limits, the sediments and 0.5 feet of the underlying clay would be removed.

Removal

The sediment removal activities would be conducted in a manner to minimize the release of volatile constituents, and also to minimize the amount of water that is generated, which potentially would contain EDC and require treatment. Two potential removal options were considered in detail and are presented below. Removal options would continue to be evaluated during the design phase and the option used for removal may be modified somewhat from that presented herein.

Option 1 (Removal with Vacuum Trucks)

- Portable water diversion structures would be installed on the upstream and downstream ends of localized removal areas, and removal would progress from the West Ditch downstream to Bayou Verdine, and then from upstream to downstream within the bayou.
- Removal would be conducted in localized sections of the West Ditch Area. Portable pumps would be used to pump the water from removal areas and also to divert water from the upstream water diversion structure to the downstream structure.
- Removal would be conducted with vacuum trucks and the sediments would be pumped directly into sealed vacuum boxes. Excavation equipment may be used to loosen and scrape the stiffer sediment and underlying clay to the target removal depth and then to feed this material to the vacuum hoses.

- The exhaust from the vacuum trucks would be treated onsite using either vapor-phase carbon or a combination wet scrubber and vapor-phase carbon.

- Any water entering the excavation would be pumped to frac tanks and then to an approved wastewater treatment system. As necessary, shallow sheet piles or other vertical barrier would be driven into the clay in order to contain seepage from the sides.

- The vacuum boxes would be allowed to sit and the material to settle out. Water accumulating at the top of the boxes would be periodically decanted and pumped to an approved wastewater treatment system.

Option 2 (Removal with Hybrid Dredge)

- Removal would be conducted with a combination mechanical and hydraulic dredge equipped with a sealed clam-shell bucket. This type of dredge can remove the material at the in-situ water content with minimal resuspension as compared to other dredging technologies.

- Portable water diversion structures would be installed on the upstream and downstream ends of localized removal areas, and removal would progress from the West Ditch downstream to Bayou Verdine, and then from upstream to downstream within the bayou. Water from upstream would be diverted around the removal areas, but sufficient water would be maintained within the removal area to float the dredge and also to maintain a water blanket to minimize the release of volatile organics.

- The dredge material would be placed in a hopper located on the shoreline. The hopper would have a flexible membrane cover and be under negative air pressure so that when the dredge bucket is opened to deposit the material into the hopper, the volatile emissions would be contained. From the hopper, the material would be pumped to a series of sealed filter boxes where water separated from the sediments can be removed and pumped to an approved wastewater treatment system.

- The air exhaust from the negative air device on the hopper, the air displaced from the boxes, and any other exhaust that potentially could contain volatile emissions would be treated onsite with vapor-phase carbon or a combination wet scrubber and vapor-phase carbon.

- The localized areas beneath the Old Trousdale Road Bridge would be removed with either vacuum trucks (as described above) or a small suction-type dredge.

Placement of Barrier System and Cover

After removal within an area using either one of the options described above, a barrier system would be placed on top of the underlying clay. The barrier system would consist of two layers. After removal within an area using either one of the options described above, a barrier system would be placed on top of the underlying clay. Conceptually, the barrier system would consist of three layers. From the bottom up, the layers are:

1. A barrier layer directly on top of the clay to impede the vertical movement of water and sediments;
2. A protective layer to protect the barrier layer; and
3. A sand/silt cover material at the surface to provide a substrate with a texture similar to natural conditions (minimum of one-foot thick).

It is possible that layers 1 and 2 can be combined into one layer by using a rigid uniform mat of low permeability. There are three barrier system configurations under consideration.

Option 1 - Option 1 would use a grout-injected, fabric-formed, semi-rigid, continuous, 3 to 6-inch liner as both the barrier and protective layer. The technology that would be used to install this layer is commonly referred to as "fabri-forming" or "uniform section lining." Two geotextiles joined together at closely spaced points with drop-strings would be placed on the bayou bottom after removal activities within a section are complete. The interstitial spacing between the geotextiles would be filled by pumping with a grout mixture consisting of sand, cement and bentonite. The drop strings control the layer thickness. During the design phase, the appropriate thickness would be determined, and the grout mixture would be designed to provide the appropriate balance of both sealing/flexibility and rigid protectiveness. After the grout was allowed to cure, the minimum 1-foot sand/silt cover layer would be placed.

Option 2 - Option 2 would use a geosynthetic clay layer (GCL) for a barrier, a combination of sand and light riprap for a protective layer, and then the sand/silt layer as cover material. A GCL is a manufactured composite liner consisting of a layer of low-permeability sodium bentonite attached to a fabric or geomembrane. Typically GCLs are shipped in rolls that when deployed are less than 0.25 inches thick. GCL placement requires further evaluation before this option can be selected. There are two concerns; first, the GCL and overlying sand with riprap must be placed at the same time to assure uniform GCL loading as it hydrates; and second, Bayou Verdine water is brackish and the effect of salt water on the GCL permeability must be evaluated. The GCL would be protected by a minimum of 6 inches of sand to evenly distribute the weight of individual riprap rock. Approximately 6 inches of light riprap (i.e., 2-pound stone) would be placed over the GCL and the sand cover to provide protection to the barrier layer. A minimum 1-foot sand/silt cover layer would be placed on top of the riprap.

Option 3 - Option 3 would use an HDPE geomembrane for a barrier, a light riprap for protection, and then the sand/silt layer as cover material. To protect the geomembrane, a minimum 6-inch layer of sand would be placed on the geomembrane before the protective layer is placed. Approximately 6 inches of light riprap (i.e., 2-pound stone) would be placed on the geomembrane sand cover as the protective layer. A minimum 1-foot sand/silt cover layer would be placed on top of the riprap.

Figure 5-3 shows three potential options for the barrier system and cover. The details of the barrier system to be used for implementation of the alternative will continue to be evaluated during the design phase and may be modified somewhat from that presented herein.

Onsite Thermal Desorption

Onsite thermal desorption would be implemented as follows:

- After removal, the sediments would be transported to a centralized staging area.
- The sediments would be dewatered with either a belt filter press or centrifuge and the filter cake would be treated with an onsite thermal desorption unit.

- The effluent from the dewatering operation and the liquid condensed from the desorption unit would be sent to a closed top frac tank constructed with baffles to separate out any non-aqueous phase EDC.
- It is assumed that the EDC liquid would be sent offsite for recycling and the water would be treated at an approved wastewater treatment system.
- As an onsite CERCLA action, permitting of the thermal desorption unit would not be required, but the unit would have to comply with the substantive requirements of a permit, including appropriate, storage and handling procedures and appropriate emission controls.
- It is assumed that the treated materials could be disposed of as nonhazardous waste.

Post-Construction Monitoring

Because the affected sediments would be removed, there would not by any subsequent post-construction monitoring of the West Ditch Area.

Effectiveness

Overall Protection of Human Health and the Environment - Alternative WD-3 would be protective because it would eliminate exposure pathways to human and ecological receptors above the removal action concentration established in Section 4.2.

Compliance with ARARs - The alternative could be implemented to comply with the action-specific and location-specific ARARs listed in Table 5-1. A USACE permit would not be required, but the action would have to comply with the substantive requirements of Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act.

LDEQ and USEPA regulations regarding the handling and transportation of hazardous waste would apply. The selected disposal facility would have to have approval to accept CERCLA waste.

It is assumed that some of the material would be classified as a D028 characteristic hazardous waste and therefore be subject to land disposal restrictions until the characteristic is removed.

As an onsite CERCLA action, hazardous waste permitting of the thermal desorption unit would not be required, but would have to comply with the substantive requirements of a permit.

Treatment and discharge of generated waters would have to comply with the substantive requirements of the Louisiana Pollution Discharge Elimination System program.

There have not been any federally-listed threatened and endangered (T&E) species or archeological or historical sites identified within the area to be addressed by the removal action.

<u>Long-Term Effectiveness and Permanence</u> - Alternative WD-3 would involve permanent removal of contaminated sediments from the West Ditch Area. The barrier system would permanently prevent any future exposure to the underlying clay material.

<u>Reduction of Toxicity, Mobility, and Volume</u> - There would be a reduction in toxicity and volume with thermal desorption and the treated materials would be put in a landfill. There would be a decrease of volume of contaminated sediments.

<u>Short-Term Effectiveness</u> - A Site-specific Health and Safety Plan would be required to ensure protection of remediation workers during all phases of planning, construction and monitoring of this option. The Health and Safety Plan should also address the necessary procedures to eliminate any potential exposures to people outside the work area. Appropriate engineering and monitoring controls would be evaluated and implemented as needed in order to protect the remediation workers, plant workers and community from any unacceptable exposure arising from the alternative. Emissions would be difficult to control around the dewatering and thermal desorption operations. There is a potential for releases of constituents down the bayou during the removal action; however, this potential would be mitigated through the use of the water diversion structures and the removal methods described above.

The action would take approximately 6-9 months to implement.

Implementability

Alternative WD-3 would be difficult to implement. Removal is assumed to be either with a hybrid dredge or vacuum truck, which would be slow. Monitoring and engineering measures to control vapors may also cause some delays. Temporary diversion of the bayou would be difficult and there are concerns about ability to control the flow. It may not be feasible to divert the bayou during storm events and therefore localized removal areas would have to be completed or protected prior to storm flow. It would be difficult to handle and desorb wet sediments. Bench-scale testing would be required prior to full-scale desorption. It would be also difficult to control vapor emissions around the dewatering and thermal desorption units.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. A detailed cost spreadsheet is presented in Appendix C.

Alternative WD-3 Removal and Onsite Thermal Desorption		
Estimated Capital Cost ($)	**Estimated Present Worth O&M Cost ($)**	**Estimated Present Worth Total Cost ($)**
6,380,000	0	6,380,000

5.3.1.4 Alternative WD-4 – Containment/Capping

Alternative WD-4 would consist of covering the West Ditch Area sediments that are above the removal action concentration with a Gabion Mattress Containment System.

Gabions are flexible wire mesh baskets that are typically filled with earth or stone and used as support structures. The gabion mattress system that would be used consists of rectangular units that are divided into cells typically 6 feet wide with diaphragms spaced at 3-foot intervals. A continuous panel of mesh forms the base, the sides, and the end walls of the unit to form an open-top multi-cell container. The system would be filled with soil or stone to provide a permanent barrier over the contaminated sediments.

The following are the major components of Alternative WD-4:

- Pre-construction activities would consist of additional hydraulic studies to determine the appropriate material type to be placed in the gabions and to determine the appropriate thickness of the mattress. It is expected that the mattress would be either 0.5 or 1-foot thick. The thickness of the mattress placed in the bayou may be greater than the thickness of the mattress placed in the West Ditch. An evaluation would also be conducted to select a material type for the gabions that is compatible with EDC. It should be noted, however, that after the systems described below are in place and established, the wire mesh of the gabions would no longer be necessary to contain the cover system.

- Pre-construction and post-construction surveying would be conducted of the bayou and West Ditch to document the elevation change due to placement of the containment system.

- Post-construction monitoring would be conducted as appropriate.

There are two potential options that may be used for the containment system. Option 1 would consist of stone-filled gabions, and Option 2 would consist of soil-filled gabions. Figure 5-4 illustrates these two options and they are described below:

<u>Option 1 (Stone-Filled Gabions)</u>

- A nonwoven geotextile (for filtration) and woven geotextile (for strength and separation) would be placed over the sediments.

- A network of gabion mattresses would be sequentially connected together and filled with graded stone on the shore adjacent to the bayou and the West Ditch.

- The gabions would be floated or lifted into position in a manner to prevent disturbance of the sediments.
- Sand or silt material would be placed to fill the interstitial spaces around the stone.

The stones within the gabions would prevent erosion of the interstitial sand/silt while providing a competent physical barrier that would prevent direct contact with the underlying sediments. The sand or silt matrix would provide a substrate suitable for establishment of the benthic community.

Option 2 (Soil-Filled Gabions)

- A nonwoven geotextile would be placed over the sediments, and also within the bottom of the mattress system.
- A network of gabion mattresses would be sequentially connected together and filled with soil material on the shore adjacent to the bayou and the West Ditch. The soil material would be a sand/clay mixture typical of the existing substrate.
- Another nonwoven geotextile would be sewn over the top of the soil material prior to placing the lids.
- The gabion mattresses would be floated or lifted into position in a manner to prevent disturbance of the sediments.

The overlying geotextile would retain the sediments within the gabions. After the gabion mattresses are placed over sediments, a reinforced geomat blanket would be connected to the lid of the gabions and placed up the side slopes and anchored. The geomat blanket increases the soil's resistance to erosion by providing an environment that enhances the growth of vegetation through the mat. With deposition, there would also be establishment of some vegetative growth on the mattress, particularly at the margins. The mattress may be seeded or planted to promote the growth of desirable vegetation. Additional hydraulic studies would be required to properly size the material placed in the gabions and evaluate whether there would be any erosion of the cover. A preliminary hydraulic analysis indicates that at low flows, the water surface rise just upstream of the mattress is estimated to be about 0.2 feet for both a 9 inch and 6 inch mattress (the difference between the two mattress thicknesses is insignificant). It is expected that this increase would be dissipated upstream over a distance estimated to be about 300 feet in Bayou Verdine and 230 feet in the West Ditch.

Post-construction monitoring would consist of surveying the containment area to demonstrate that erosion is not occurring. A 5-year monitoring period is assumed.

Effectiveness

Overall Protection of Human Health and the Environment - Alternative WD-4 would be protective because it would eliminate exposure to human and ecological receptors above the removal action concentration established in Section 4.2.

Compliance with ARARs - The alternative could be implemented to comply with the action-specific and location-specific ARARs listed in Table 5-1. A USACE permit would not be required, but the action would have to comply with the substantive requirements of Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act.

There have not been any federally-listed threatened and endangered (T&E) species or archeological or historical sites identified within the area to be addressed by the removal action.

Long-Term Effectiveness and Permanence - Alternative WD-4 would be effective at preventing exposure to contaminated sediments in the West Ditch Area. Additional hydraulic studies would be conducted during the design phase to size material to be placed in the gabions to ensure that they would not erode and the system would be permanent.

Reduction of Toxicity, Mobility, and Volume - There would be no reduction in inherent toxicity or volume other than a slow decrease in concentrations of organic compounds over time as the material naturally degrades. Effective toxicity (availability) and mobility would be further reduced in the covered area.

Short-Term Effectiveness - A Site-specific Health and Safety Plan would be required to ensure protection of remediation workers during all phases of planning, construction and monitoring of this option. The Health and Safety Plan should also address the necessary procedures to eliminate any potential exposures to people outside the work area. Appropriate engineering and monitoring controls would be evaluated and implemented as needed in order to protect the remediation workers, plant workers and community from any unacceptable exposure arising from the alternative. With placement of the mattress, the underlying contaminated sediments would consolidate and potentially release some EDC to the water column. The effects of these releases are uncertain. There is also a potential for releases of constituents down the bayou during placement of the system; silt curtains would be installed to reduce releases.

The action would take approximately 2 months to implement.

Implementability

Alternative WD-4 would be moderately difficult to implement. The mattress would have to be filled on shore and floated out over the area in sections to minimize suspension of sediments. It may be difficult to control lateral movement of the soft sediments (i.e., a mud wave) when placing the mattress. The periodic flooding of the bayou may make placement difficult.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. A detailed cost spreadsheet is presented in Appendix C.

Alternative WD-4 Containment/Capping		
Estimated Capital Cost ($)	**Estimated Present Worth O&M Cost ($)**	**Estimated Present Worth Total Cost ($)**
1,070,000	20,000	1,090,000

5.3.2 Main Channel

The following four alternatives were evaluated for the Main Channel:

- Alternative MC-1 - Natural Recovery
- Alternative MC-2 - Dredging and Offsite Disposal
- Alternative MC-3 - Dredging and Onsite Consolidation
- Alternative MC-4 - Containment/Capping

5.3.2.1 Alternative MC-1 – Natural Recovery

Alternative MC-1 is natural recovery. Site risks would be reduced by natural sedimentation and degradation of organics in the Main Channel. Alternative MC-1 also includes hydrodynamic and sedimentation studies as well as sediment sampling to evaluate the effectiveness of natural recovery. Baseline monitoring and development of a long-term monitoring plan would be conducted during the first year. Subsequent monitoring would include:

- Annual sediment sampling for site constituents to determine whether concentrations are decreasing with natural recovery.
- Annual surveying of sediment pins at specified locations to quantify the amount of deposition (if any) that is occurring.

It is assumed that the monitoring program would be conducted for a 10-year period.

Effectiveness

Overall Protection of Human Health and the Environment - Natural recovery is likely occurring as less contaminated sediments are deposited in the bayou and mix with existing sediments thus reducing the concentrations. Natural recovery is also occurring with the degradation of organic constituents. These natural recovery processes would cause a decrease in Site risks. The monitoring conducted for Alternative MC-1 would provide data for evaluating the effectiveness of these processes.

Compliance with ARARs - None of the location-specific ARARs identified for the site would pertain to Alternative MC-1. There would be no action-specific ARARs.

Long-Term Effectiveness and Permanence - There would be increased protectiveness with natural recovery of the system; however long-term effectiveness and permanence is uncertain and would be determined from monitoring.

Reduction of Toxicity, Mobility, and Volume - There would be a slow reduction in toxicity, mobility and volume as organic compounds degrade over time. Effective toxicity (availability) and mobility will gradually decrease as concentrations in the active zone decrease with natural recovery.

Short-Term Effectiveness - There would be no short-term adverse effects associated with this alternative.

Implementability

Implementability - Alternative MC-1 is easily implementable from a technical basis.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. A detailed cost spreadsheet is presented in Appendix C.

Alternative MC-1 Natural Recovery		
Estimated Capital Cost ($)	**Estimated Present Worth O&M Cost ($)**	**Estimated Present Worth Total Cost ($)**
190,000	460,000	650,000

The estimated capital costs are for the baseline studies and development of a long-term monitoring plan. The O&M costs are for the subsequent monitoring over a 10-year period.

5.3.2.2 Alternative MC-2 – Dredging and Offsite Disposal

Alternative MC-2 would consist of dredging the sediments and transporting them offsite for disposal at a permitted landfill as a nonhazardous material. The dredging would result in a very significant reduction in the mass of contaminants in the bayou. However, it is anticipated that there will be some residual contamination in the remaining sediments and this residual contamination will be addressed through natural recovery. The natural recovery processes includes biodegradation of the organics and natural deposition of new sediments within the bayou. Post-removal sampling will be conducted to measure the progress of natural recovery in the surficial sediment layer.

Dredging

Dredging would be done using a small hydraulic dredge. One pass would be made over the areas identified in Figure 5-2 to remove a nominal 1-foot of material. An additional pass would be made over the northern section of Reach 1 (as identified on Figure 5-2) to remove an additional 1-foot of material. The dredge would be equipped with either an auger or cutterhead. The auger type dredge utilizes a cable to position and move the dredge throughout the dredging area. The dredge excavates material by moving forward in a series of parallel lines with each pass slightly overlapping the previous one. The cutterhead dredge operates using a swinging motion of the dredge head. Both types of dredges can be positioned using conventional surveying equipment or global positioning systems (GPS) to ensure that coverage of the entire channel is obtained and the specified depth of material is removed.

Engineering controls, such as proper selection of the speed and depth of cut of the dredge, would be implemented to minimize resuspension. Additional controls (e.g., silt curtain) may be implemented to contain suspended sediments on the downstream boundary of the active dredging.

From the geotechnical testing described in Section 2.5.1 and information from other dredging projects, it is estimated that a total of approximately 360,000 cubic yards of material (5% solids and 95% water) would be dredged, and during the assumed 160 days of active dredging approximately 400,000 gallons per day of excess water would be generated and treated.

Dredged material would be pumped through an 8-inch diameter high density polyethylene (HDPE) pipe. This pipe would be placed on floats within the bayou and would be carefully routed to avoid obstructions when on land.

A temporary holding pond would be constructed at the site (Figure 5-5). The pond would be built by constructing perimeter earthen berms to hold approximately 5,000 cubic yards of dredged materials. This capacity would allow about 2 days holding time for the total volume of material (sediment and water) estimated to be dredged daily. The temporary holding pond would be lined with a 40 mil HDPE geomembrane and would require an area of about 250 feet by 250 feet. Disposal of the HDPE liner at the disposal facility has been included in the cost analysis. The earthen levee would be left in place or graded upon completion. The dredged material would be directed to the temporary holding pond where settling would occur. The material would be pumped through a mixing tank with filter aids. The water generated during dredging would be pumped through a multimedia filter and routed to the facility wastewater treatment system. The sediments would be dewatered using a filter press and the solid material would be loaded onto tractor-trailers and transported offsite to the disposal facility. Figure 5-6 shows this sequence.

Post -Removal Sampling

Post-removal sampling would be conducted to measure the progress of natural recovery in the surficial sediment layer, which is the bioaccessible zone. One round of samples would be collected six months to one year after completion of the dredging and the results would provide a baseline for evaluating the natural recovery processes. If warranted[4], a second round of samples would be collected during the fifth year following completion of the dredging. The sampling would consist of the following:

- The dredged areas of the bayou would be divided into six approximately equal sections.
- Five surficial sediment samples would be collected from random locations within each section. To the extent practicable, the 5-year sampling event would target the sediments that had been deposited since the dredging.

4 If the first round of sampling indicates that the remedial action objectives have been achieved without further natural recovery, the second round of sampling would not be performed. This determination would be made by USEPA based on a review of the first round sampling results.

- The samples would be composited into one sample per section; and
- The six composite samples would be analyzed for PAHs.

Effectiveness

Overall Protection of Human Health and the Environment - Alternative MC-2 would provide additional protection to ecological receptors. The dredging would result in a very significant mass reduction by targeting areas where sediment constituents have the greatest potential to impact Site risk and removing these contaminated sediments from the bayou. With any dredging technology there would be some resuspension and settling out of contaminated sediments, which may leave residual contamination. The residual contamination would be addressed with natural recovery. As described above, engineering controls would be implemented to minimize resuspension.

Compliance with ARARs - The alternative could be implemented to comply with the action-specific and location-specific ARARs listed in Table 5-1. A USACE permit would not be required, but the action would have to comply with the substantive requirements of Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act.

There have not been any federally-listed threatened and endangered (T&E) species or archeological or historical sites identified within the area to be addressed by the removal action.

The discharge water from the dewatering operation would be directed to the Conoco wastewater treatment system. This may require modification of the existing LPDES permit for the remediation water.

The bayou sediment material would not be classified as a listed hazardous waste under 40 CFR 261. Based on knowledge of the material and the low constituent concentrations, it is assumed that the material would not be classified as a characteristic hazardous waste. Therefore, after dewatering, it is assumed the sediment could be transported and disposed of as a nonhazardous waste. It would be sent to a facility that has the authority to accept CERCLA waste.

Long-Term Effectiveness and Permanence -The dredging would result in permanent removal of a very significant mass of contaminants from the bayou. The dredged material would be sent to a permitted landfill. Natural recovery would address the residual contamination.

Reduction of Toxicity, Mobility, and Volume - There may be a temporary increase in mobility and availability of constituents due to resuspension during dredging. There would be a long-term decrease in the mobility and effective toxicity (availability) of contaminants in the sediments that are removed and placed in a secure landfill. There would be a decrease in the volume of contaminated sediments in the bayou.

Short-Term Effectiveness - A Site-specific Health and Safety Plan would be required to ensure protection of remediation workers during all phases of planning, construction and monitoring of this option. The Health and Safety Plan should also address the necessary procedures to eliminate any potential exposures to people outside of the work area. Appropriate engineering and monitoring controls would be evaluated and implemented as needed in order to protect the remediation workers, plant workers and community from any unacceptable exposure arising from the alternative. There is a small potential for exposure to the community during transportation of the material to the offsite incinerator/disposal facility due to accidental discharge resulting from a traffic accident or other similar incident. This potential would be minimized with proper selection, training and oversight of subcontractors.

The action would take approximately 6 to 9 months to implement.

Implementability

Alternative MC-2 would be moderately difficult to implement. Shallow water and bayou crossings may impede dredging progress. There is potential for underwater obstructions that could make dredging difficult, and there are other logistical concerns related to access and transporting sediments long distances via a pipeline. The fine-grained sediments and high organic content may make dewatering difficult. The variable water levels in the bayou may also impede the dredging process.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. A detailed cost spreadsheet is presented in Appendix C.

Alternative MC-2 Dredging and Offsite Disposal		
Estimated Capital Cost ($)	**Estimated Present Worth O&M Cost ($)**	**Estimated Present Worth Total Cost ($)**
7,340,000	0	7,340,000

5.3.2.3 Alternative MC-3 – Dredging and Onsite Consolidation

Alternative MC-3 would consist of dredging the sediments into the Trousdale Road Ponds, allowing the dredged material to settle out and dewater, constructing a soil cover over the Trousdale Road Ponds, and then regrading the area consistent with the surrounding topography. The dredging would result in a very significant reduction in the mass of contaminants in the bayou. However, it is anticipated that there will be some residual contamination in the remaining sediments and this residual contamination will be addressed through natural recovery. The natural recovery processes includes biodegradation of the organics and natural deposition of new sediments within the bayou. Post-removal sampling will be conducted to measure the progress of natural recovery in the surficial sediment layer. Post-closure monitoring would also be conducted for the Trousdale Road Ponds.

Dredging

Dredging would be done using a small hydraulic dredge. One pass would be made over the areas identified in Figure 5-2 to remove a nominal 1-foot of material. An additional pass would be made over the northern section of Reach 1 (as identified on Figure 5-2) to remove an additional 1-foot of material. The dredge would be equipped with either an auger or cutterhead. The auger type dredge utilizes a cable to position and move the dredge throughout the dredging area. The dredge excavates material by moving forward in a series of parallel lines with each pass slightly overlapping the previous one. The cutterhead dredge operates using a swinging motion of the dredge head. Both types of dredges can be positioned using conventional surveying equipment or global positioning systems (GPS) to ensure that coverage of the entire channel is obtained and the specified depth of material is removed.

Engineering controls, such as proper selection of the speed and depth of cut of the dredge, would be implemented to minimize resuspension. Additional controls (e.g., silt curtain) may be implemented to contain suspended sediments on the downstream boundary of the active dredging.

From the geotechnical testing described in Section 2.5.1 and information from other dredging projects, it is estimated that a total of approximately 360,000 cubic yards of material (5% solids and 95% water) would be dredged, and during the assumed 160 days of active dredging approximately 400,000 gallons per day of excess water would be generated and treated.

Dredged material would be pumped through an 8-inch diameter HDPE pipe. This pipe would be placed on floats within the bayou and would be carefully routed to avoid obstructions when on land.

Trousdale Road Ponds

The two ponds proposed for consolidation of the dredged sediments for this alternative are labeled Pond A and Pond B on Figure 5-7. These ponds are referred to collectively as the "Trousdale Road Ponds". The ponds are irregular in shape, have bottom elevations of about -10 feet NGVD (Pond A), and -6 feet NGVD (Pond B), and have fairly steep side slopes in some areas. Pond A has an approximate surface area of 217,000 square feet, and Pond B has a surface area of about 174,000 square feet. As shown on Figure 5-7, there is a direct connection between the bayou and Pond A via a ditch. The direction of water flow between the ponds and Bayou Verdine depends on the hydraulic conditions (i.e., tides, stream flow in Bayou Verdine, and surface drainage into the ponds during periods of rainfall).

The ponds have been sampled two times (March 1983 and March 1994). The most relevant data is from the 1994 sampling event. Composite sediment samples were collected from both Pond A and Pond B in 1994. The samples were analyzed for volatile organic constituents, semivolatile organic constituents and the 8 RCRA metals. These results were compared to results from Bayou Verdine sediment (Table 2-2 and Table 2-3) and the findings indicate that the contaminants in the ponds are similar to those detected in the bayou. The results are summarized below:

	Parameter	Result (mg/kg wet weight)
East Pond (Pond A) Sample	Total Petroleum Hydrocarbons	30,000
	Barium	64.4
	Chromium	16.1
	Arsenic	1.55
	Lead	8.98
	Ethylbenzene	0.017
	Phenanthrene	0.55
	Pyrene	0.73
	Bis(2-ethylhexyl)phthalate	0.67
	Benzo(a)anthracene	1.2
	Chrysene	1.3
West Pond (Pond B) Sample	Total Petroleum Hydrocarbons	12,000
	Barium	65.4
	Chromium	21.6
	Lead	8.88
	Ethylbenzene	0.073
	Total Xylenes	0.022

Consolidation, Construction of Soil Cover and Regrading

As the dredged materials are pumped to the Trousdale Road Ponds, the excess water within the ponds would be displaced and pumped through a multimedia filter and to the facility wastewater treatment system. An evaluation of the data from the treatability testing and the estimated water production rates indicate that the facility wastewater treatment system has the capability and sufficient capacity to treat the water from the dredging operation. The dredged material placed into the ponds would be allowed to settle and consolidate. Any additional water generated during consolidation would also be pumped back to the Conoco wastewater treatment system after treatment through the multimedia filter.

After the dredged material consolidates in the ponds, a soil cover system would be constructed over the consolidated material. An existing onsite soil stockpile would be used for cover material along with soils from the adjacent upland area and other onsite sources or an approved offsite source. Three composite samples were collected from the onsite stockpile and geotechnical tests were conducted for particle-size analysis (ASTM D 422-63). The soil is classified as a CL material using the Unified Soil Classification System (USCS). The three samples contained sand ranging from

31.7% to 35.6%, silt ranging from 34.9% to 41.8%, and clay ranging from 23.3% to 33.4%. The stockpile material appears to be suitable cover material.

It is assumed that the consolidation of the material in the ponds would take an extended period of time, as long as or longer than 6 months. During this time period, water would be periodically pumped off of the pond surfaces and through the multimedia filter to the wastewater treatment system. After the material from the dredging operation is allowed to consolidate and dewater in the ponds, a geotextile would be placed over the dredged material for separation. A geogrid would be rolled out over the geotextile to provide reinforcement. The geogrid would be tied or joined together by an approved method. This geosynthetic combination would provide a suitable base for heavy equipment and provide support for the overlying cover layer. An access road would be constructed and the soil material would be placed onto the geosynthetics. A lightweight bulldozer with low ground pressure tracks would be used to place material to create a grade consistent with the surrounding topography. The area will be vegetated with grasses or other appropriate upland plants to maintain the integrity of the cover. Figure 5-7 shows the existing topography in the vicinity of the Trousdale Road ponds. Figure 5-8 shows the estimated final grade. Figure 5-9 is a schematic cross-section of the Trousdale Road Ponds after placement of the final cover.

Post-Removal Sampling and Monitoring

Post-removal sampling would be conducted to measure the progress of natural recovery in the surficial sediment layer, which is the bioaccessible zone. One round of samples would be collected six months to one year after completion of the dredging and the results would provide a baseline for evaluating the natural recovery processes. If warranted[5], a second round of samples would be collected during the fifth year following completion of the dredging. The sampling would consist of the following:

- The dredged areas of the bayou would be divided into six approximately equal sections.

[5] If the first round of sampling indicates that the remedial action objectives have been achieved without further natural recovery, the second round of sampling would not be performed. This determination would be made by USEPA based on a review of the first round sampling results.

- Five surficial sediment samples would be collected from random locations within each section. To the extent practicable, the 5-year sampling event would target the sediments that had been deposited since the dredging.
- The samples would be composited into one sample per section; and
- The six composite samples would be analyzed for PAHs.

Post-closure monitoring would be conducted for the Trousdale Road Ponds. Monitoring wells around the Trousdale Road Ponds would be used to monitor upgradient and downgradient groundwater conditions in the uppermost water-bearing zone adjacent to the ponds. There may be existing monitor wells that can be used for this purpose. It is assumed that groundwater monitoring would be conducted on a semiannual basis for a 5-year period. There would also be monitoring of the competency of the cover system and maintenance of the cover as needed during this 5-year period.

Effectiveness

Overall Protection of Human Health and the Environment - Alternative MC-3 would provide additional protection to ecological receptors. The dredging would result in a very significant mass reduction by targeting areas where sediment constituents have the greatest potential to impact Site risk, and removing these contaminated sediments from the bayou. With any dredging technology there would be some resuspension and settling out of contaminated sediments, which may leave residual contamination. The residual contamination would be addressed with natural recovery. As described above, engineering controls would be implemented to minimize resuspension.

Compliance with ARARs - The alternative could be implemented to comply with the action-specific and location-specific ARARs listed in Table 5-1. A USACE permit would not be required, but the action would have to comply with the substantive requirements of Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. Consolidation of the material in the Trousdale Road Ponds is consistent with USEPA's Area of Contamination Policy as described in 55 FR 8758-8760.

There have not been any federally-listed threatened and endangered (T&E) species or archeological or historical sites identified within the area to be addressed by the removal action.

The discharge water from the dredging operation would be directed to the Conoco wastewater treatment system. This may require modification of LPDES for the remediation water.

Long-Term Effectiveness and Permanence - The dredging would result in permanent removal of a very significant mass of contaminants from the bayou. Natural recovery would address the residual contamination. The constituents in the dredged material are relatively immobile and would be secure in the Trousdale Road Ponds.

Reduction of Toxicity, Mobility, and Volume - There may be a temporary increase in mobility and availability of constituents due to resuspension during dredging. There would be a long-term decrease in the mobility and effective toxicity (availability) of contaminants that are removed from the bayou and placed in the ponds. There would be a decrease in the volume of contaminated sediment in the bayou.

Short-Term Effectiveness - A Site-specific Health and Safety Plan would be required to ensure protection of remediation workers during all phases of planning, construction and monitoring of this option. The Health and Safety Plan should also address the necessary procedures to eliminate any potential exposures to people outside of the work area. Appropriate engineering and monitoring controls would be evaluated and implemented as needed in order to protect the remediation workers, plant workers and community from any unacceptable exposure arising from the alternative.

The removal action would take approximately 6 to 9 months to implement. Depending on the efficiency of dewatering in the ponds, it may take more than 6 months of settling before the cover can be placed.

Implementability

Alternative MC-3 would be moderately difficult to implement. Shallow water and bayou crossings may impede dredging progress. There is potential for underwater obstructions that could make dredging difficult, and there are other logistical concerns related to access and piping sediments long distances. The variable water levels in the bayou may also impede the dredging progress.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. A detailed cost spreadsheet is presented in Appendix C.

Alternative MC-3 Dredging and Onsite Consolidation		
Estimated Capital Cost ($)	**Estimated Present Worth O&M Cost ($)**	**Estimated Present Worth Total Cost ($)**
4,990,000	80,000	5,070,000

The estimated capital costs are for dredging and capping the Trousdale Road Ponds and regrading the area. The O&M costs are for the subsequent monitoring of the closed Trousdale Road Ponds over a 10-year period.

5.3.2.4 Alternative MC-4 – Containment/Capping

Alternative MC-4 would consist of covering the bayou channel sediment areas shown on Figure 5-2 with the AquaBlok™ composite particle system. For purposes of this EE/CA AquaBlok™ was selected over other containment options because it can be placed with minimal disturbance to surrounding habitat and would provide a substrate suitable for the Bayou Verdine environment. Other potential cover materials would be evaluated during the design phase.

AquaBlok™ is a proprietary, composite-aggregate mixture of clay or clay-size minerals, polymers and other special additives surrounding a dense aggregate nucleus. In most cases the clay component of AquaBlok™ is largely bentonite clay; however, other clay materials (attapulgite or organoclays) or clay-sized materials can also be incorporated to meet project or site-specific requirements. AquaBlok™ was developed primarily for encapsulating in-situ contaminated sediments and can also provide a substrate for wetland vegetation as well as habitat for some macroinvertebrate organisms (AquaBlok™, Technical Papers and Website).

After placement in the water, the AquaBlok™ particles fall to the substrate and expand into a continuous and cohesive erosion resistant layer of low permeability (Figure 5-10). This layer forms a physical, hydraulic and chemical resistant barrier that separates the contaminated sediments from the overlying water column and the biota in the bayou.

AquaBlok™ would be placed with either a shore-based conveyer or a helicopter (Figure 5-11). It is assumed that the AquaBlok™ barrier would be between 6 and 8 inches thick. Pre-application activities would consist of bench-scale testing and application planning. Some site preparation activities would be required in areas where shore-based application would be used. Most areas to be covered have limited site access. It is estimated that approximately 80 percent of the area to be covered with AquaBlok™ would be placed by helicopter. In other areas access to the bayou would be by clearing and construction of access roads. The disturbance to other areas would be kept to a minimum.

Post-Closure Monitoring

The integrity of the AquaBlok™ cover would be monitored. The monitoring program would consist of annual surveying to determine whether there has been any erosion or deterioration of the cover, and also to evaluate whether sediment deposition has occurred. Sediment pins may also be employed and monitored for this purpose.

Effectiveness

Overall Protection of Human Health and the Environment - Alternative MC-4 would provide additional protection to ecological receptors by covering areas where sediment constituents have the greatest potential to impact Site risk, thus isolating these areas from potential receptors. There may not be complete coverage or a consistent thickness in all the areas covered by AquaBlok™.

Compliance with ARARs - The alternative could be implemented to comply with the action-specific and location-specific ARARs listed in Table 5-1. A USACE permit would not be required, but the action would have to comply with the substantive requirements of Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act.

There have not been any federally-listed threatened and endangered (T&E) species or archeological or historical sites identified within the area to be addressed by the removal action.

Long-Term Effectiveness and Permanence - The capping would result in isolation of constituents that contribute most to Site risks and preventing exposure. Due to low flow in the bayou, the AquaBlok™ material is not expected to erode. However, the potential for erosion and compatibility with site conditions would have to be determined prior to placement of the AquaBlok™. Incomplete coverage is also a concern.

Reduction of Toxicity, Mobility, and Volume - There would be a slow reduction in inherent toxicity and volume due to degradation of the organics over time. Effective toxicity (availability) and mobility would be reduced in the covered areas.

Short-Term Effectiveness - A Site-specific Health and Safety Plan would be required to ensure protection of remediation workers during all phases of planning, construction and monitoring of this option. The Health and Safety Plan should also address the necessary procedures to eliminate any potential exposures to people outside of the work area. Appropriate engineering and monitoring controls would be evaluated and implemented as needed in order to protect the remediation workers, plant workers and community from any unacceptable exposure arising from the alternative.

The remedy would take approximately 4 to 6 months to implement.

Implementability

Alternative MC-4 would be moderately difficult to implement. Due to Site access, AquaBlok™ application would be by helicopter for approximately 80 percent of the covered areas. There is the potential for incomplete and inconsistent coverage. The applicability of the AquaBlok™ technology to site conditions would have to be determined with bench scale and/or field scale testing prior to full scale use. Because the technology is not widely used, scheduling is a concern.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. A detailed cost spreadsheet is presented in Appendix C.

Alternative MC-4 Containment/Capping		
Estimated Capital Cost ($)	**Estimated Present Worth O&M Cost ($)**	**Estimated Present Worth Total Cost ($)**
2,620,000	90,000	2,710,000

The estimated capital costs are for placement of the AquaBlok™ material. The O&M costs are for the subsequent monitoring of the cover in the bayou over a 5-year period.

This section presents a comparative analysis of the alternatives based on the three EE/CA evaluation criteria of effectiveness, implementability and cost. A semi-quantitative rating system is used to rate the relative performance of each alternative. Effectiveness is given more emphasis with each of the five effectiveness subcriteria assigned 3 possible points, for a total possible 15 rating points. Implementability and cost were assigned 5 possible rating points each. The comparative analysis for the West Ditch Area is presented in Section 6.1 and summarized in Table 6-1. The comparative analysis for the Main Channel is presented in Section 6.2 and summarized on Table 6-2.

6.1 WEST DITCH AREA

Effectiveness

Overall Protection of Human Health and the Environment

The alternatives were evaluated against their ability to provide additional protection for human and ecological receptors by targeting sediments above the calculated EDC concentration goal. Alternative WD-1 rates the lowest with respect to overall protection of human health and the environment because there would not be any action to reduce Site risks beyond that which occurs naturally with sedimentation and degradation. Alternatives WD-2 (Removal and Offsite Incineration/Disposal) and WD-3 (Removal and Onsite Thermal Desorption) remove constituents from the system and therefore provide greater protection than the containment/capping alternative (WD-4).

Based on the above analysis, the rating of these alternatives for overall protection of human health and the environment is as follows (rating score of 3 indicates the highest relative performance against the criterion, score of 0 the least):

- Alternatives WD-2 and WD-3 were given a rating score of 3.
- Alternative WD-4 was given a rating score of 2.
- Alternative WD-1 was given a rating score of 0.

Compliance with ARARs

All of the alternatives could be implemented to comply with the identified action-specific and location-specific ARARs. Compliance with Section 404 of the Clean Water Act, the LPDES permit requirements for water management, and compliance with the land disposal restrictions are the most critical to the implementation. Alternative WD-3 would also have to comply with the substantive requirements of permitting a hazardous waste unit but an actual permit would not be required. All four alternatives were given a rating score of 3.

Long-Term Effectiveness and Permanence

The removal alternatives (WD-2 and WD-3) are similar with respect to long-term effectiveness because the contaminated sediments would be permanently removed from the West Ditch Area. After removal, the material would be either sent to a commercial incinerator or other disposal facility (WD-2) or treated onsite with a thermal desorber and the treated material sent to a permitted landfill (WD-3). The containment alternative (WD-4) is rated as less effective and permanent because contaminated sediments would be left in place. Alternative WD-1 rates the lowest because the effectiveness of natural recovery is uncertain.

Based on the above analysis, the rating of these alternatives for long-term effectiveness and permanence is as follows (rating score of 3 indicates the highest relative performance against the criterion, score of 0 the least):

- Alternatives WD-2 and WD-3 were given a rating score of 3.
- Alternative WD-4 was given a rating score of 2.
- Alternative WD-1 was given a rating score of 0.

Reduction of Mobility, Toxicity, or Volume

With all four of the alternatives there would be a decrease in effective toxicity (availability) and mobility resulting from removal, containment or natural recovery. Alternative WD-2 (Removal and Offsite Incineration/Disposal) and WD-3 (Removal and Onsite Thermal Desorption) rate the highest for this criterion. They both involve treatment technologies that reduce the toxicity and volume of contaminants and then dispose of the treated materials in a permitted landfill.

Containment/Capping (Alternative WD-4) rates higher than Natural Recovery (Alternative WD-1) due to the greater reduction in mobility and effective toxicity caused by the containment.

Based on the above analysis, the rating of these alternatives against mobility, toxicity, and volume reduction is as follows (rating score of 3 indicates the highest relative performance against the criterion, score of 0 the least):

- Alternatives WD-2 and WD-3 were given a rating score of 3.
- Alternative WD-4 was given a rating score of 1.
- Alternative WD-1 was given a rating score of 0.

<u>Short-Term Effectiveness</u>

The removal alternatives (WD-2 and WD-3) potentially would have the most adverse short-term effects. Emissions would be difficult to control around the dewatering and thermal desorption operations for Alternative WD-3 and therefore it is rated lower that Alternative WD-2 for this criterion. Alternative WD-2 (Removal and Offsite Incineration/Disposal) also has a small potential for exposure to the community during transportation of the material to the offsite incinerator due to accidental discharge resulting from a traffic accident or other similar incident. This potential would be minimized with proper selection, training and oversight of subcontractors. There is a potential for releases of constituents down the bayou during the removal action; however, this potential would be mitigated through engineering controls during removal. For the containment alternative (WD-4), the underlying contaminated sediments would consolidate and potentially release some EDC to the water column; the effects of these releases are uncertain.

Based on the above analysis, the rating of these alternatives for short-term effectiveness is as follows (rating score of 3 indicates the highest relative performance against the criterion, score of 0 the least):

- Alternative WD-1 was given a rating score of 3.
- Alternative WD-4 was given a rating score of 2.
- Alternative WD-2 was given a rating score of 1.
- Alternative WD-3 was given a rating score of 0.

Implementability

The removal action alternatives (WD-2 and WD-3) would be moderately difficult to implement. Removal is assumed to be either with a hybrid dredge or vacuum truck, which would be slow. Monitoring and engineering measures to control vapors may also cause some delays. Temporary diversion of the bayou would be difficult and there are concerns about ability to control the flow. It may not be feasible to divert the bayou during storm events and therefore localized removal areas would have to be completed or protected prior to storm flow. Alternative WD-2 (Removal and Offsite Incineration/Disposal) is rated higher than Alternative WD-2 (Removal and Onsite Thermal Desorption) because it would be difficult to handle and desorb wet sediments and bench-scale testing would be required prior to full-scale implementation.

Alternative WD-4 would also be moderately difficult to implement. The mattress would have to be filled on shore and floated out over area in sections to minimize suspension of sediments. It may be difficult to control lateral movement of the soft sediments (i.e., a mud wave) when placing the mattress. The periodic flooding of the bayou may make placement difficult.

Alternative WD-1 is easily implementable from a technical basis.

Based on the above analysis, the rating of these alternatives for implementability is as follows (rating score of 5 indicates the highest relative performance against the criterion, score of 0 the least):

- Alternative WD-1 was given a rating score of 4.
- Alternatives WD-2 and WD-4 were given a rating score of 2.
- Alternative WD-3 was given a rating score of 1.

Cost

The estimated costs for the alternatives are summarized below:

Alternative	Capital Cost ($)	Present Worth O&M Cost ($)	Total Present Worth Cost ($)
Alternative WD-1	100,000	160,000	260,000
Alternative WD-2	7,100,000	0	7,100,000
Alternative WD-3	6,380,000	0	6,380,000
Alternative WD-4	1,070,000	20,000	1,090,000

Based on the above analysis, the rating of these alternatives for cost is as follows (rating score of 5 indicates the highest relative performance against the criterion, score of 0 the least):

- Alternative WD-1 was given a rating score of 4.
- Alternative WD-4 was given a rating score of 3
- Alternatives WD-2 and WD-3 were given a rating score of 1.

West Ditch Area Summary

Table 6-1 summarizes the rating scores for the four West Ditch Area removal action alternatives. Alternative WD-2 (Dredging and Offsite Incineration/Disposal) ranks the highest for effectiveness (13 out of a possible 15 rating points) and also has the highest composite score.

6.2 MAIN CHANNEL

Overall Protection of Human Health and the Environment

The alternatives were evaluated against their ability to provide additional protection for ecological receptors by targeting the areas within the Main Channel where sediment constituents have the greatest potential to impact Site risk. Alternative MC-1 rates the lowest with respect to overall protection because there would not be any action to reduce Site risks beyond that which occurs naturally with sedimentation and biodegradation. The dredging alternatives (Alternative MC-2 and

MC-3) remove constituents from the system and therefore provide more protection than containment (Alternative MC-4).

Based on the above analysis, the rating of these alternatives for overall protection of human health and the environment is as follows (rating score of 3 indicates the highest relative performance against the criterion, score of 0 the least):

- Alternatives MC-2 and MC-3 were given a rating score of 3.
- Alternative MC-4 was given a rating score of 2.
- Alternative MC-1 was given a rating score of 0.

Compliance with ARARs

All of the alternatives could be implemented to comply with the identified action-specific and location-specific ARARs. Compliance with the substantive requirements of Section 404 of the Clean Water Act and the LPDES permit requirements for water management are the most critical to the implementation. All four alternatives are given a rating score of 3.

Long-Term Effectiveness and Permanence

The long-term effectiveness of Alternative MC-1 is uncertain without additional studies on sedimentation and biodegradation. The dredging alternatives (MC-2 and MC-3) are similar with respect to long-term effectiveness because dredging will result in permanent removal of contaminated sediments from the bayou. After removal, the dredged material will be secured in a landfill (for Alternative MC-2) or in onsite ponds (for Alternative MC-3). Alternative MC-4 (Containment/Capping) rates lower than the dredging alternatives because there are uncertainties associated with the long-term stability of the AquaBlok™ cover. The potential for erosion and compatibility with Site conditions would have to be determined prior to placement of the AquaBlok™.

Based on the above analysis, the rating of these alternatives for long-term effectiveness and permanence is as follows (rating score of 3 indicates the highest relative performance against the criterion, score of 0 the least):

- Alternatives MC-2 and MC-3 were given a rating score of 3.
- Alternative MC-4 was given a rating score of 2.
- Alternative MC-1 was given a rating score of 0.

Reduction of Mobility, Toxicity, or Volume

With all four of the alternatives there would be a decrease in effective toxicity (availability) and mobility resulting from sedimentation and natural recovery. Alternatives MC-2, MC-3 and MC-4 provide added reductions due to the containment and removal actions. Alternative MC-4 (Containment/Capping) would be effective at reducing mobility and availability because the residual material would be covered, but the volume of contaminated sediments in the bayou would not be reduced. The dredging alternatives (Alternatives MC-2 and MC-3) would reduce the volume of contaminated sediments in the bayou and also would provide an ultimate reduction in mobility and availability by placing the material within secure containment. With dredging, however, there may be an immediate short-term increase in both these parameters from resuspension of sediments during dredging. Engineering controls would be implemented to minimize resuspension. There would be some resuspension with Alternative MC-4, but it would be less than with dredging.

Based on the above analysis, the rating of these alternatives against mobility, toxicity, and volume reduction is as follows (rating score of 3 indicates the highest relative performance against the criterion, score of 0 the least):

- Alternatives MC-2 and MC-3 were given a rating score of 2.
- Alternative MC-4 was given a rating score of 1
- Alternative MC-1 was given a rating score of 0.

Short-Term Effectiveness

The dredging alternatives (MC-2 and MC-3) would have the most adverse short-term effects with removal of the sediments. A Site-specific Health and Safety Plan would be required to ensure protection of remediation workers during all phases of planning, construction and monitoring of this option. The Health and Safety Plan should also address the necessary procedures to eliminate any potential exposures to people outside of the work area. Appropriate engineering and monitoring controls would be evaluated and implemented as needed in order to protect the remediation workers, plant workers and community from any unacceptable exposure arising from the alternative. Alternative MC-2 (Removal and Offsite Disposal) also has a small potential for exposure to the community during transportation of the material to the disposal facility due to accidental discharge resulting from a traffic accident or other similar incident. This potential would be minimized with proper selection, training and oversight of subcontractors.

Based on the above analysis, the rating of these alternatives for short-term effectiveness is as follows (rating score of 3 indicates the highest relative performance against the criterion, score of 0 the least):

- Alternative MC-1 was given a rating score of 3.
- Alternative MC-4 was given a rating score of 2.
- Alternatives MC-2 and MC-3 were given a rating score of 1.

Implementability

The dredging alternatives (MC-2 and MC-3) would be moderately difficult to implement due to the shallow water, bayou crossings, potential for underwater obstructions and logistical concerns related to access and piping sediment long distances. Alternative MC-3 would be more difficult to implement than MC-2 because the fine-grained sediments and high organic content would make dewatering difficult.

Due to technical feasibility issues, Alternative MC-4 (Containment/Capping) is considered more difficult to implement than the dredging alternatives (MC-2 and MC-3). The AquaBlok™ technology is not very mature. There is poor access to the bayou shoreline and AquaBlok™ application would be by helicopter for approximately 80 percent of the covered areas; the feasibility of attaining adequate and consistent coverage with a helicopter is a concern. Bench scale and/or field scale testing would be required to determine the applicability of AquaBlok™ to the Site conditions. The technology is not widely used so scheduling may also be an issue.

Alternative MC-1 is easily implementable from a technical basis.

Based on the above analysis, the rating of these alternatives for implementability is as follows (rating score of 5 indicates the highest relative performance against the criteria, score of 0 the least):

- Alternative MC-1 was given a rating score of 4.
- Alternative MC-3 was given a rating score of 3.
- Alternative MC-2 was given a rating score of 2.
- Alternative MC-4 was given a rating score of 1.

Cost

The estimated costs for the alternatives are summarized below:

Alternative	Capital Cost ($)	Present Worth O&M Cost ($)	Total Present Worth Cost ($)
Alternative MC-1	190,000	460,000	650,000
Alternative MC-2	7,340,000	0	7,340,000
Alternative MC-3	4,990,000	80,000	5,070,000
Alternative MC-4	2,620,000	90,000	2,710,000

Based on the above analysis, the rating of these alternatives for cost is as follows (rating score of 5 indicates the highest relative performance against the criteria, score of 0 the least):

- Alternative MC-1 was given a rating score of 5.
- Alternative MC-4 was given a rating score of 4.
- Alternative MC-3 was given a rating score of 3.
- Alternative MC-2 was given a rating score of 2.

Main Channel Summary

Table 6-2 summarizes the rating scores for the Main Channel area alternatives. Alternative MC-2 (Dredging and Offsite Disposal) and Alternative MC-3 (Dredging and Onsite Consolidation) rank the highest for effectiveness (12 out of a possible 15 rating points). Alternative MC-3 has the highest composite score because it rates better for implementability and cost than Alternative MC-2.

Considering the relative performance of the alternatives against the EE/CA evaluation criteria summarized on Table 6-1 and 6-2, the recommended removal action alternatives are Alternative WD-2 (Removal and Offsite Incineration/Disposal) for the West Ditch Area and Alternative MC-3 (Dredging and Onsite Consolidation) for the Main Channel. These alternatives are summarized below:

WEST DITCH AREA - Sediments will be removed from the West Ditch Area and transported offsite for incineration/disposal. A barrier system and cover will then be placed over the underlying clay.

Removal - The removal action will include sediments within the West Ditch Area that are above the risk-based removal action concentration, and 0.5 feet of the underlying clay. Sediment removal will be conducted in a manner to minimize the release of volatile constituents, and also to minimize the amount of water that is generated. Two potential removal options are presented in this EE/CA, removal with a vacuum truck and removal with a hybrid mechanical/hydraulic dredge. The selected removal option will be determined in the design phase. Temporary diversion structures will be installed to divert the bayou during the removal activities.

Off-Site Incineration/Disposal - Some of the material removed from the West Ditch Area will likely be subject to land disposal restrictions. Accordingly, this material will be transported offsite to a permitted commercial hazardous waste incinerator. Excavated materials that are not subject to land disposal restrictions will be disposed of at an offsite disposal facility permitted to accept the waste.

Barrier System and Cover - A barrier system will be constructed on top of the underlying clay. Conceptually, the barrier system will consist of the following three layers from the bottom up:

1. A barrier layer directly on top of the clay to impede the vertical movement of water and sediments;
2 A protective layer to protect the barrier layer; and
3 Sand/silt cover material to provide a substrate with a texture similar to natural conditions (minimum of one-foot thick).

There are three options for barrier system configurations presented in this EE/CA. The configuration to be use will be determined in the design phase.

MAIN CHANNEL - Sediments will be dredged from sections within the Bayou Verdine channel. The dredged material will be pumped to the Trousdale Road Ponds (two ponds located on the west side of the Conoco facility) where the sediments will settle out and consolidate. A soil cover will be constructed over the Trousdale Road Ponds, the area will be regraded and vegetation will be established. Post-construction monitoring of the Trousdale Road Ponds will be conducted.

Dredging - Sediments will be dredged from sections within Reaches 1 and 2 of the Bayou Verdine channel that have the greatest potential to impact Site risks. The dredging will consist of one pass with a small hydraulic dredge to remove the upper nominal 1-foot of sediments. A second pass will be made over the northern section of Reach 1 to remove an additional 1-foot of material.

Consolidation - The dredged sediments will be pumped to the Trousdale Road Ponds. The sediments in the Trousdale Road Ponds will be allowed to settle and dewater, and the water will be pumped through a multimedia filter and then to Conoco's permitted Wastewater Treatment facility.

Cover Placement - After consolidation, a geotextile and geogrid will be placed over the dredged material in the ponds to provide a suitable base for heavy equipment and the overlying cover layer. A soil cover will be placed over the geotextile/geogrid and the area will be regraded to be consistent with the surrounding topography. The area will be vegetated with grasses or other appropriate upland plants to maintain the integrity of the cover.

Monitoring - Groundwater monitoring will be conducted for the Trousdale Road Ponds and there will also be monitoring of the competency of the cover system. A 5-year monitoring period is assumed.

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TABLES

FIGURES

APPENDIX A

GRAIN SIZE DISTRIBUTION CURVES

APPENDIX B

TREATABILITY TEST ANALYTICAL RESULTS

APPENDIX C

COST TABLES

ATTACHMENT 1

SUMMARY OF BIOAVAILABILITY ISSUES FOR ARSENIC IN BAYOU VERDINE HHRA